DNO COMMON NETWORK ASSET INDICES METHODOLOGY

01/08/2016

Health & Criticality - Version 1.0

A common framework of definitions, principles and calculation methodologies, adopted across all GB Distribution Network Operators, for the assessment, forecasting and regulatory reporting of Asset Risk.

VERSION CONTROL

Version No.	Date	Description	Outcome
Draft v3	01/07/2015	Formal Draft Submission to Ofgem	Ofgem Direction requesting changes received 23/10/2015
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v1.0	01/08/2016	As implemented	

This document is subject to change control in accordance with SLC 51 Part I: Modification of the Common Network Asset Indices Methodology. Any changes made to the methodology must be directed by Ofgem and recorded in the table above.

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PURPOSE OF DOCUMENT

This document sets out a common methodology for assessing condition-based risk for electricity distribution assets. It has been developed by the six GB DNO groups in satisfaction of the requirements of Standard Condition 51 (SLC 51) of the electricity distribution licence for RIIO-ED1 (1 April 2015 to 31 March 2023).

The document sets out the overall process for assessing condition-based risk and specifies the parameters, values and conditions to be used. The collective outputs of the assessment, used for regulatory reporting purposes, are known as the Network Asset Indices under the Common Network Asset Indices Methodology. The methodology can be amended subject to the change process outlined in SLC51.

When approved by Ofgem, this methodology will require DNOs to re-align their current processes and practices to this new standard. It will also require a re-basing of the Network Risk targets agreed between the DNOs and Ofgem for the RIIO-ED1 period under the provisions of CRC5D of the RIIO-ED1 licence which are contained within the Network Assets Workbook.

Once implemented, DNOs will be required to report annually against the targets set using the methodology to calculate the changes achieved. These reporting requirements are set down in Annex D to the RIIO-ED1 Regulatory Instructions and Guidance (RIGs).

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1. GLOSSARY

Term	Definition
Ageing Rate	A parameter that describes the rate of deterioration of Asset Health with age.
Ageing Reduction Factor	A factor that slows down the Ageing Rate of older assets.
Asset Category	A generic term to describe a group of asset types where a particular input, calculation or calibration within the Common Network Asset Indices Methodology is common.
Asset Health	Represents the condition of an asset measured against a common set of condition factors.
Asset Register Category	Groupings of asset type that are used in reporting the asset population in Ofgem's RIIO-ED1 RIGs. Asset Register Categories are used as Asset Categories within this document, where appropriate.
Asset Replacement	An activity defined in Ofgem's RIIO-ED1 RIGs: Annex A – Glossary to remove an existing asset(s) and install a new asset.
Average Overall Consequence of Failure	The mean average of the Overall Consequence of Failure for all assets within the same Health Index Asset Category.
Catastrophic Failure	A sudden or total functional failure of an asset (or a subcomponent), from which recovery of the asset (and/ or sub component) is impossible.
Condition-based Functional Failure	The inability of an asset to perform its required function, as a consequence of the condition of asset. This includes: • failures disruptive to the supply of electricity; • catastrophic failures of equipment or subcomponents; • failure of an asset to operate (or be operated) when required; and • failure of an asset to perform its rated duty.
Condition Cap	A maximum limit of Health Score, which forms part of a Condition Modifier.
Condition Collar	A minimum limit of Health Score, which forms part of a Condition Modifier.
Condition Factor	A Factor, which forms part of a Condition Modifier.
Condition Input	Result of an observation or test, used to evaluate the health of an asset.
Condition Input Cap	A maximum limit of Health Score associated with a particular Condition Input.
Condition Input Collar	A minimum limit of Health Score associated with a particular Condition Input.
Condition Input Factor	A Factor associated with a particular Condition Input.
Condition Modifier	A Modifier based on a set of observed or measured Condition Inputs.
Consequence Categories	Categories relating to the different areas that may be impacted by asset failure. The categories represent areas where the Consequences of Failure can be separately evaluated.
Consequences Factor	A Factor applied to the Reference Cost of Failure in order to determine the Consequences of Failure of an asset.
Consequences of Failure	The impact of Condition-based Functional Failure of an asset.
Criticality Index	This is a framework for collating information on the Consequences of Failure of distribution assets and for tracking changes over time. The Criticality Index is a comparative measure of Consequence of Failure. For a particular asset, the Criticality Index is provided by:- • the location of the asset within the Criticality Index Bands; and • the Average Overall Consequence of Failure, for the relevant Health Index Asset Category
Criticality Index Banding Criteria	The criteria used to define the Criticality Index Bands, expressed as a percentage of the Average Overall Consequence of Failure for each Health Index Asset Category.
Criticality Index Bands	Bandings used for the reporting of the Overall Consequence of Failure for individual assets, relative to the Average Overall Consequence of Failure for assets in the same Health Index Category.
Current Health Score	The Health Score calculated for an asset that represents the Asset Health at the time (i.e. in the year) of calculation.
Degraded Failure	A functional failure of an asset (or a subcomponent), from which the asset (and/ or sub component) can be restored, but it may not be cost effective to do so.
DGA Test Modifier	A Condition Modifier applied to EHV Transformer and 132kV Transformer assets, based on the results of dissolved gas analysis.
Duty Factor	A Factor representing the effect that duty has on the Expected Life of an asset.
Expected Life	The time (in years) in an asset's life when it would be expected to first observe significant deterioration (Health Score 5.5), taking into consideration location or duty, in addition to the asset type.
Factor	A multiplication value, varying around unity.
FFA Test Modifier	A Condition Modifier applied to EHV Transformer and 132kV Transformer assets, based on measurements of furfuraldehyde (FFA) in oil.
Future Health Score	The Health Score(s) calculated for an asset that represents the Asset Health in any year beyond the current year.

Term	Definition
Health Index	A framework for collating information on the Asset Health of distribution assets. This framework shall enable:- • tracking of changes in Asset Health over time; and • identification of the Probability of Failure associated with the asset condition. For a particular asset, the reported Health Index is provided by the location of the asset within the Health Index Bands.
Health Index Asset Category	Asset categorisations, used within the Network Assets Workbook, for which DNOs have agreed Secondary Deliverables. Health Index Asset Categories are used as Asset Categories within this document, where appropriate.
Health Index Banding Criteria	The criteria used to define the Health Index Bands.
Health Index Bands	Bandings used for the reporting of the Health Indices for individual assets, based on the Probability of Failure indicated by each assets health and condition.
Health Score	A numerical value representing a measure of Asset Health.
Health Score Cap	A maximum limit applied to the Health Score, associated with a particular condition point.
Health Score Collar	A minimum limit applied to the Health Score, associated with a particular condition point.
Health Score Factor	A Factor based on one or more Condition Modifiers.
Health Score Modifier	A Modifier applied to the Initial Health Score of assets.
Incipient Failure	A functional failure of an asset (or a subcomponent), which if unaddressed may lead to a degraded or catastrophic failure.
Initial Health Score	The Health Score calculated for an asset, based solely on age-based criteria.
Location Factor	A Factor representing the effect that the environment, in which the asset is installed, has on it's Expected Life.
Measured Condition Input	A Condition Input associated with the measured condition of an asset
Methodology	For the purposes of this document, the Methodology means the Common Network Asset Indices Methodology.
Modifier	A value derived from factors, used to modify a base value within the Asset Health calculation.
Network Asset Secondary Deliverables	Secondary Deliverables relating to Asset Health, criticality and risk, as defined for the RIIO-ED1 period in Standard Condition 51 of the electricity distribution licence.
Normal Expected Life	The time (in years) in an asset's life when it would be expected to first observe significant deterioration (Health Score 5.5), based on consideration of the asset type alone.
Observed Condition Input	A Condition Input associated with the observed condition of an asset
Oil Test Modifier	A Condition Modifier applied to EHV Transformer and 132kV Transformer assets, based on oil test measurements.
Overall Consequence of Failure	The total Consequence of Failure for an asset, taking account of the Consequences of Failure in all Consequence Categories.
Probability of Failure	The likelihood of a Condition-based Functional Failure occurring (per annum).
Reference Costs of Failure	A base evaluation of the Consequences of Failure in a particular Consequence Category.
Refurbishment	A one-off activity, defined in Ofgem's RIIO-ED1 Regulatory Instructions and Guidance: Annex A – Glossary that is undertaken on an asset that is deemed to be close to end of life or is otherwise not fit for purpose that extends the life of that asset or restores its functionality.
Reliability Collar	A minimum limit of Health Score, which forms part of a Reliability Modifier.
Reliability Factor	A Factor, which forms part of a Reliability Modifier.
Reliability Modifier	A Modifier applied (at individual DNO discretion) to the Current Health Score of assets.
Risk Index	Has the meaning given in Standard Condition 51 of the electricity distribution licence.
Risk Matrix	The 5x4 matrix formed by the Health Index and Criticality Index respectively

2. ACRONYMS

Acronym	Description
AAAC	All Aluminium Alloy Conductors
ACB	Air Circuit Breaker
ACSR	Aluminium Conductor Steel Reinforced
Cad Cu	Cadmium Copper
CI	Customer Interruption
CML	Customer Minutes Lost
CMR	Continuous Maximum Rating
CoF	Consequence of Failure
CRC	Charge Restriction Condition
DGA	Dissolved Gas Analysis
DIN	Dangerous Incident Notification
DNO	Distribution Network Operator
DP	Degree of Polymerisation
DPCR5	Distribution Price Control Review for five years from 1 April 2010 to 31 March 2015
DSI	Death or Serious Injury
EHV	Extra High Voltage
ENA	Energy Networks Association
EoL	End of Life
ESQCR	Electricity, Safety, Quality and Continuity Regulations 2002
FFA	Furfuraldehyde
FFC	Fluid Filled Cable
GB	Great Britain
GM	Ground Mounted
HI	Health Index
HSE	Health and Safety Executive or Health, Safety and Environment
HV	High Voltage
ID	Indoor
IIS	Interruption Incentive Scheme
IR	Insulation Resistance
kV	Kilovolt
LV	Low Voltage
LV UGB	Low Voltage Underground Board (Link Box)
LTA	Lost Time Accident
MMI	Maximum and Multiple Increment
MVA	Megavolt Ampere
NaFIRS	National Fault and Interruption Reporting Scheme
NAW	Network Assets Workbook
NEDeRs	National Equipment Defect Reporting Scheme
OD	Outdoor
Ofgem	Office of Gas and Electricity Markets
OHL	Overhead Line
PM	Pole Mounted
PoF	Probability of Failure
RIG	Regulatory Instructions and Guidance
RIIO	Ofgem's price control framework first implemented in 2013
RIIO-ED1	First price control for Electricity Distribution companies under the RIIO framework
RMU	Ring Main Unit
SDI	Secondary Deliverable Intervention
SF_6	Sulphur Hexafluoride
SLC	Standard Licence Condition
SOP	Suspension of Operational Practice
VoLL	Value of Lost Load
VSL	Value of Statistical Life
WM	Wall Mounted

3. INTRODUCTION

For RIIO-ED1, which runs from 1 April 2015 to 31 March 2023, Ofgem has introduced regulatory reporting requirements for GB DNOs to report information relating to both Asset Health and criticality. This information is known as the Network Asset Indices, and these provide an indication of the risk of condition-based failure of network assets.

The requirement for reporting of Network Asset Indices is outlined in Standard Licence Condition 51. This licence condition also requires DNOs to jointly develop a Common Network Asset Indices Methodology, such that DNOs adopt a common approach to the reporting of indices that measure Asset Health and Criticality.

This document details the Common Network Asset Indices Methodology (herein referred to as “the Methodology”) to be applied.

In RIIO-ED1, DNOs have Network Asset Secondary Deliverables relating to Network Asset Indices. These relate to the improvement in risk that is delivered by Asset Replacement, as well as some Refurbishment activities. Such activities are referred to as Interventions.

The Asset Categories where Network Asset Secondary Deliverables have been agreed as part of the RIIO-ED1 settlement may differ between DNOs. Each DNO is only required to report Network Asset Indices for Asset Categories where they have agreed these Secondary Deliverables. Consequently, DNOs are only required to implement the Common Network Asset Indices Methodology for those Asset Categories where they are to report Network Asset Indices. This methodology covers all Asset Categories that have been agreed.

3.1 Network Asset Indices Methodology Objectives

Standard Licence Condition 51 Part D states the following:

The Network Asset Indices Methodology Objectives are that compliance with the Common Network Asset Indices Methodology enables:

a) the comparative analysis of network asset performance between Distribution Service Providers over time;

b) the assessment of the licensee's performance against the Network Asset Secondary Deliverables; and

c) the communication of information affecting the Network Asset Secondary Deliverables between the licensee, the Authority and, as appropriate, other interested parties in a transparent manner.

The Methodology details the inputs, calculations and calibration parameters to be used in the calculation of Asset Health and criticality. This means that, where the Methodology is applied, a common output shall be determined for a common set of input data. This facilitates use of the output for comparative analysis. For the avoidance of doubt, all values for parameters outlined within this document are fixed and shall be adhered to in the application of the Methodology.

The communication of information relating to the Network Asset Secondary Deliverables, and their delivery, shall be through risk matrices (showing Asset Health and criticality). These are required for regulatory reporting purposes. The output from the Methodology will be used for the population of these risk matrices.

3.2 Asset Health and Probability of Failure

Asset Health is a measure of the condition of an asset and the proximity to the end of its useful life. The Methodology includes a common methodology for the calculation of Asset Health for individual assets. This includes:-

i) current Asset Health informed by observed and measured condition factors; and
ii) future Asset Health, using assumptions regarding the likely future deterioration in Asset Health.

In order to take account of future deterioration it is necessary for the Methodology to:-

i) include some age-based elements within the calculation of Asset Health; and
ii) use a continuous Health Score scale for the evaluation of Asset Health.

As the health of an asset deteriorates (i.e. its condition worsens), the likelihood that it will fail due to condition increases.

The Methodology relates Asset Health to the associated probability of condition-based failure (PoF). For each asset type, the Methodology specifies the exact relationship between Health Score and PoF. Therefore Asset Health can equally be expressed in terms of PoF.

3.3 Consequences of Failure and Asset Criticality

When an asset fails, there will be an associated impact resulting from that failure. For example, there could be a loss of supply to customers, or an injury resulting from a failure. Such impacts are referred to as Consequences of Failure (CoF).

The Methodology includes a common methodology for the evaluation of the likely CoF associated with the condition-based failure of individual assets. Monetised values are determined for all CoF in £ (at 2012/13 prices).

The criticality of an asset is a relative measure of its CoF compared with the average for its asset type.

3.4 Regulatory Reporting of Network Asset Indices

For each asset, the Methodology shall determine:-

i) the PoF (per annum); and
ii) the CoF (£).

associated with condition-based failures. This information is used for the regulatory reporting of the Network Asset Indices for each asset.

The Network Asset Indices comprise three components:-

i) Health Index - which relates to Asset Health and PoF;
ii) Criticality Index - which relates to CoF; and
iii) Risk Index - this is a monetised risk measure, determined from the combination of the Health Index and Criticality Index.

The Health Index is a framework for collecting information relating to Asset Health and PoF. The Health Index consists of five bandings. Assets are allocated a Health Index Band based on the Health Score that is determined for the asset, which can be directly related to its PoF. The value of PoF associated with each of the Health Index Bands for each Health Index Asset Category is also reported.
The Criticality Index is a framework for collecting information relating to CoF. The Criticality Index consists of four bandings. Assets are allocated to a Criticality Index Band according to the

relative magnitude of the CoF of the individual asset compared to the Average CoF for the relevant Asset Category. For each Health Index Asset Category, the Average CoF is also reported.

Each reported asset is allocated to the Risk Matrix which consists of a Health Index Band and a Criticality Index Band. The Risk Index for an asset is based on its position in the Risk Matrix. By assigning a typical PoF to each Health Index Band, and a typical CoF to each Criticality Index Band, a monetised value of risk can be determined.

Separate Risk Matrices are produced to show:-

i) existing asset risk;
ii) future asset risk; and
iii) future asset risk taking account of planned interventions.

3.5 Hierarchy of Asset Categories

The Methodology applies to many different types of assets (e.g. overhead line conductor, cables, switchgear etc.).

Whilst the Methodology applies the same generic principles in evaluating health and criticality for each asset type, the inputs, calculations and calibrations differ for different types of assets.

For different asset types, this recognises variations in:-

i) the types of Condition-based Functional Failures;
ii) the evaluation of Asset Health; and
iii) the impact of failure.

Within this document the inputs, calculations and calibrations are often specified according to the type of asset. The groupings of assets used for specifying this information are referred to as Asset Categories.

There are two main types of Asset Category used within this document:-

i) Asset Register Category; and
ii) Health Index Asset Category.

The Asset Register Category represents the groupings of asset type that are used in reporting the asset population in Ofgem's RIIO-ED1 RIGs. The Asset Register Category is also used for the annual reporting of Network Asset Indices to Ofgem.

The Health Index Asset Category represents groupings of asset type at a higher level than the Asset Register Category. Each Health Index Asset Category is a grouping of one or more Asset Register Categories. For RIIO-ED1, the Network Asset Secondary Deliverables, agreed for each DNO, have been defined in terms of the risk improvement relating to individual Health Index Asset Categories.

There are minor variations between DNOs for the mapping of Asset Register Categories to Health Index Asset Category within their individual Network Asset Secondary Deliverables. For the purposes of this document, each Health Index Category is used to describe the inputs, calculations and calibrations that shall apply to assets in the Asset Register Categories shown in Table 1.

TABLE 1: CATEGORISATION OF ASSETS

Health Index Asset Category	Asset Register Category

Health Index Asset Category	Asset Register Category
LV OHL Support	LV Poles
LV UGB	LV UGB
LV Switchgear and Other	LV Board (WM) LV Board (X-type Network) (WM) LV Circuit Breaker LV Pillar (ID) LV Pillar (OD at Substation) LV Pillar (OD not at a Substation)
HV OHL Support - Poles	6.6/11kV Poles 20kV Poles
HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary 20kV CB (GM) Primary
HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary 6.6/11kV RMU 6.6/11kV X-type RMU 6.6/11kV Switch (GM) 20kV CB (GM) Secondary 20kV RMU 20kV Switch (GM)
HV Transformer (GM)	6.6/11kV Transformer (GM) 20kV Transformer (GM)
EHV OHL Support - Poles	33kV Pole 66kV Pole
EHV OHL Fittings	33kV Fittings 66kV Fittings
EHV OHL Conductor (Tower Lines)	33kV OHL (Tower Line) Conductor 66kV OHL (Tower Line) Conductor
EHV OHL Support - Towers	33kV Tower 66kV Tower
EHV UG Cable (Gas)	33kV UG Cable (Gas) 66kV UG Cable (Gas)
EHV UG Cable (Non Pressurised)	33kV UG Cable (Non Pressurised) 66kV UG Cable (Non Pressurised)
EHV UG Cable (Oil)	33kV UG Cable (Oil) 66kV UG Cable (Oil)

Health Index Asset Category	Asset Register Category
Submarine Cables	HV Sub Cable EHV Sub Cable 132kV Sub Cable
EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID) (GM) 33kV CB (Air Insulated Busbars)(OD) (GM) 33kV CB (Gas Insulated Busbars)(ID)(GM) 33kV CB (Gas Insulated Busbars)(OD)(GM) 33kV RMU 33kV Switch (GM) 66kV CB (Air Insulated Busbars)(ID) (GM) 66kV CB (Air Insulated Busbars)(OD) (GM) 66kV CB (Gas Insulated Busbars)(ID)(GM) 66kV CB (Gas Insulated Busbars)(OD)(GM)
EHV Transformer	33kV Transformer (GM) 66kV Transformer (GM)
132kV OHL Fittings	132kV Fittings
132kV OHL Conductor (Tower Lines)	132kV OHL (Tower Line) Conductor
132kV OHL Support - Tower	132kV Tower
132kV UG Cable (Gas)	132kV UG Cable (Gas)
132kV UG Cable (Non Pressurised)	132kV UG Cable (Non Pressurised)
132kV UG Cable (Oil)	132kV UG Cable (Oil)
132kV CBs	132kV CB (Air Insulated Busbars)(ID) (GM) 132kV CB (Air Insulated Busbars)(OD) (GM) 132kV CB (Gas Insulated Busbars)(ID) (GM) 132kV CB (Gas Insulated Busbars)(OD) (GM)
132kV Transformer	132kV Transformer (GM)

Within this document a number of generic terms are used to refer to higher level groupings of assets. The mapping of these generic terms to Health Index Asset Category is shown in Table 2.

TABLE 2: GENERIC TERMS FOR ASSETS

Generic Term		Health Index Asset Category
Cable	Pressurised Cable	EHV UG Cable (Oil)
		EHV UG Cable (Gas)
		132kV UG Cable (Oil)
		132kV UG Cable (Gas)
	Non Pressurised Cable	EHV UG Cable (Non Pressurised)
		132kV UG Cable (Non Pressurised)
		Submarine Cables
Switchgear		LV Switchgear and Other
		LV UGB
		HV Switchgear (GM) - Distribution
		HV Switchgear (GM) - Primary
		EHV Switchgear (GM)
		132kV CBs
Transformers	HV Transformer	HV Transformer (GM)
	Grid & Primary (or EHV & 132kV) Transformers	EHV Transformer
		132kV Transformer
Overhead Line	Poles	LV OHL Support
		EHV OHL Support - Poles
		HV OHL Support - Poles
	Towers	EHV OHL Support - Towers
		132kV OHL Support - Towers
	Fittings	EHV OHL Fittings
		132kV OHL Fittings
	OHL Conductor	EHV OHL Conductor (Tower Lines)
		132kV OHL Conductor (Tower Lines)

In some calibration tables asset subcomponents are identified. Where not explicitly stated the calibration of the Health Index Asset Category applies to all subcomponents.

Defined Asset Register Categories not covered by the Methodology are shown in Table 3.

TABLE 3: EXCLUDED ASSET REGISTER CATEGORIES

Asset Register Category	Voltage
LV Main (OHL) Conductor	LV
LV Service (OHL)	LV
LV Main (UG Consac)	LV
LV Main (UG Plastic)	LV
LV Main (UG Paper)	LV
Rising & Lateral Mains	LV
LV Service (UG)	LV
LV Service associated with RLM	LV
Cut Out (Metered)	LV
LV Transformers/Regulators	LV
6.6/11kV OHL (Conventional Conductor)	HV
6.6/11kV OHL (BLX or similar Conductor)	HV
20kV OHL (Conventional Conductor)	HV
20kV OHL (BLX or similar Conductor)	HV

Asset Register Category	Voltage
6.6/11kV UG Cable	HV
20kV UG Cable	HV
6.6/11kV CB (PM)	HV
6.6/11kV Switch (PM)	HV
6.6/11kV Switchgear - Other (PM)	HV
20kV CB (PM)	HV
20kV Switch (PM)	HV
20kV Switchgear - Other (PM)	HV
6.6/11kV Transformer (PM)	HV
20kV Transformer (PM)	HV
Batteries at GM HV Substations	HV
33kV OHL (Pole Line) Conductor	EHV
66kV OHL (Pole Line) Conductor	EHV
33kV Switchgear - Other	EHV
33kV Switch (PM)	EHV
66kV Switchgear - Other	EHV
33kV Transformer (PM)	EHV
Batteries at 33kV Substations	EHV
Batteries at 66kV Substations	EHV
132kV OHL (Pole Line) Conductor	132kV
132kV Pole	132kV
132kV Switchgear - Other	132kV
Batteries at 132kV Substations	132kV
Pilot Wire Overhead	Other
Pilot Wire Underground	Other
Cable Tunnel (DNO owned)	Other
Cable Bridge (DNO owned)	Other
Electrical Energy Storage	Other

4. OVERVIEW OF COMMON NETWORK ASSET INDICES METHODOLOGY

This section gives a high level overview of the Common network Asset Indices Methodology. Detailed explanations are given in Sections 6 and 7, with accompanying worked examples in Appendix E.

4.1 Key Outputs

The two key outputs from the Methodology are:-

i) an evaluation of PoF (the likelihood of condition-based failure per annum) for individual assets; and
ii) an evaluation of the CoF associated with condition-based failures for individual assets (i.e. the impact of a failure, expressed as a monetised value, in £).

The risk of condition-based failure, associated with an individual asset, is the product of the PoF and the CoF. Therefore, the two key outputs from the Methodology, when used together, provide information relating to condition-based risk.

PoF and CoF are calculated for all individual assets within those Health Index Asset Categories where a DNO has agreed Network Asset Secondary Deliverables. An overview of the calculation process is shown in Figure 1.

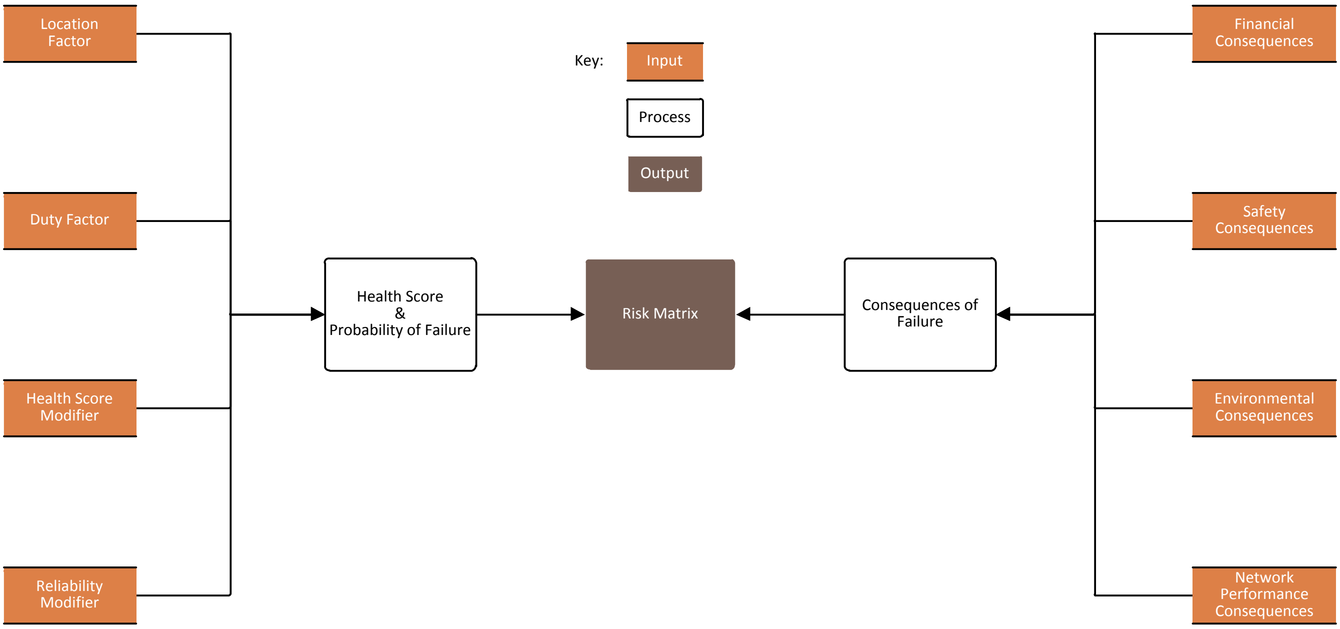

FIGURE 1: PROCESS OVERVIEW

The regulatory reporting framework for Network Asset Indices comprises three components:-

i) the Health Index, summarised in five bands HI1-5;
ii) the Criticality Index, summarised in four bands C1-4; and
iii) the Risk Index.

For regulatory reporting purposes, individual assets are assigned to a Health Index Band based on the Health Score that has been determined for the asset under the Methodology.

The evaluation of PoF is dependent on:-

i) firstly assessing Asset Health; and
ii) then deriving PoF from Asset Health.

Assets are assigned to a Criticality Index Band based on the relative magnitude of their Overall CoF, when compared to the Average Overall CoF for assets in the same Health Index Asset Category in the same DNO.

The Risk Index is a monetised risk measure that is calculated from the reported Health Index and Criticality Index information by assigning each cell in the Risk Matrix a reference risk value in £. Given the assessments above, an individual asset can be assigned a position within the Risk Matrix for that asset type.

The allocation of assets to Health Index Bands and Criticality Index Bands, and derivation of Risk Index, is described further in Section 5.

The regulatory reporting of Network Asset Indices includes the reporting of forecast future Health Index and Criticality Index for each asset, as well as the current position. This requires that the Methodology includes assessment of:-

i) current PoF and CoF; and
ii) forecast future PoF and CoF (including the assessment of changes arising from Interventions). This requires a common assessment of deterioration and a consistent view of which actions impact health and/or criticality.

4.2 Definition of Failure

The evaluation of PoF and CoF within the Methodology may be viewed as two separate distinct calculations. However, they are both based on consideration of the same set of condition-based failure modes (i.e. the same definition of what is a failure) to ensure the same set of potential events is being considered in the assessment of probabilities and consequences.

The Methodology considers Functional Failures in the derivation of PoF and CoF. These relate to the inability of an asset to adequately perform its intended function and therefore are not solely limited to failures that result in an interruption to supply.

Functional failures have been split into three sub-categories (Functional Failure Types), these are described as follows:

TABLE 4: DESCRIPTION OF FUNCTIONAL FAILURE TYPES

Functional Failure Type	Description
Catastrophic	A sudden and total failure from which recovery of the asset (and or sub component) is not feasible.
Degraded	A significant failure associated with advanced degradation.
Incipient	A minor failure associated with early stage degradation.

The Functional Failures considered in the Methodology are defined for each Asset Category, in Appendix A. These relate only to Functional Failures directly resulting from the condition of the asset itself. Failures of function due to third party activities are not included.

4.3 Evaluation of Current Asset Health and Probability of Failure

4.3.1 Overview

This section describes how current Asset Health is calculated and used to derive an associated PoF. Worked examples of this calculation can be found in Appendix E.

4.3.2 Current Health Score

The current health of an asset is represented by a Health Score (the Current Health Score) using a continuous scale between 0.5 and 10.

A value of 0.5 on this scale represents an asset where the health is the same as would be expected for a new asset. A Health Score of 5.5 represents the point in an asset's life beyond which significant deterioration may begin to be observed. This is where the PoF of the asset is approximately double that of a new asset. A Health Score of 10 represents an asset in extremely poor condition, where the PoF is 10 times that of a new asset.

The Current Health Score for an individual asset is derived from information relating to:-

i) the age of the asset;
ii) the Normal Expected Life for an asset of its type;
iii) factors relating to aspects of the environment in which the asset is installed that may impact on its Expected Life (Location Factors);
iv) factors relating to the usage of the asset at its specific location that may impact on its Expected Life (Duty Factors);
v) factors relating to the observed condition of the asset (Observed Condition Inputs);
vi) factors relating to the condition/health of the asset determined by measurements, tests or functional checks (Measured Condition Inputs); and
vii) a factor relating to generic reliability issues associated with the individual make and type of an asset (Reliability Modifier).

The calculation of Current Health Score is performed in two main steps:-

i) calculation of an initial age-based Health Score (the Initial Health Score) using an age-based degradation model; then
ii) modification of the Initial Health Score using:-
    - known condition information for the asset; and
    - a Reliability Modifier, if appropriate.

These two steps are described in more detail below:-

i) <u>Calculation of the Initial Health Score</u>

The Initial Health Score is calculated from the age of the asset and its Expected Life. The Expected Life for the asset is the Normal Expected Life for an asset of its type, adjusted to take account of the Location Factors and Duty Factors relating to the individual asset's location and usage.

A generic exponential relationship between age and health is used to determine the Initial Health Score. The shape of the exponential curve is dependent on the Expected Life of the asset.

The Initial Health Score is capped at a value of 5.5, so that an asset is not assigned a Current Health Score that implies that it has reached the end of its useful life purely on the basis of its age.

The Methodology defines the calculation of Initial Health Score for all Asset Categories. This includes definitions of the Location Factor and Duty Factor to be applied, and their calibration parameters. Therefore an asset in any DNO Licence Area with the same age, type, location and duty attributes will be assigned the same Initial Health Score using the Methodology.

The steps to calculate the Initial Health Score are detailed in Sections 6.1.3 to 6.1.6.

ii) <u>Modification of the Initial Health Score</u>

The Current Health Score is determined by application of a Health Score Modifier, and separate Reliability Modifier, to the Initial Health Score.

A Health Score Modifier is determined for each individual asset, using information relating to the asset's condition. This information can be broadly categorised as either:-

- Observed Condition Inputs; or
- Measured Condition Inputs.

Observed Condition Inputs relate to condition information that can be gathered by the inspection of an asset. However, it is not always possible to gather observed condition data without undertaking intrusive inspection.

Alternatively diagnostic tests, measurements or functional checks may be undertaken to ascertain the health of the asset. Measured Condition Inputs relate to condition information that is collected in this way.

The Methodology defines various Observed Condition Inputs and Measured Condition Inputs that can be used to determine the Health Score Modifier for an asset, including their calibration parameters.

These Condition Inputs and the methodology for determining the values for the Health Score Modifier are detailed in Sections 6.7 to 6.13.

The application of the Health Score Modifier to the Initial Health Score is described in Section 6.1.7.

It may be appropriate to apply a Reliability Modifier in the derivation of the Current Health Score (as detailed in Section 6.14). This is applied to take account of assets, where in individual DNO or industry experience, there are asset type or make issues leading to material differences in the reliability of the asset. Where a DNO applies a Reliability Modifier to a particular type of asset, this shall be described within their own Network Asset Indices Methodology.

In recognition that different inspection and assessment approaches exist between DNOs, there is no requirement for data to be collected to apply all the Condition Inputs specified within the Methodology.
Where DNOs have collected the same condition information for an asset, application of the Methodology shall result in the same Health Score Modifier values being determined for the asset. As there is commonality in the derivation of the Initial Health Score, an

asset in any DNO with the same age, type, location, duty and collected condition information will be assigned the same Current Health Score using the Methodology, except where a Reliability Modifier is applied.

The Reliability Modifier is applied at the final stage of the calculation of Current Health Score so that its effect on the Current Health Score can be directly observed.

The Current Health Score is capped at a value of 10.

4.3.3 Current Probability of Failure

For each Asset Category, the relationship between Health Score and PoF is defined within the Methodology. The current PoF is derived from the Current Health Score. This is described in Section 6.

As this relationship and its calibration values are defined, the PoF for assets will be identical where the Health Score and Asset Category are the same. This means that an asset in the same health is considered to have the same likelihood of condition-based failure irrespective of which DNO it is installed in.

4.4 Evaluation of Future Asset Health and Probability of Failure

4.4.1 Overview

The evaluation of future PoF assumes that as an asset ages in the future then its health will deteriorate and consequently the PoF will increase. This is performed by evaluating the forecast future Asset Health for the asset and then deriving the associated PoF.

4.4.2 Future Health Score

The Future Health Score is derived using similar age-based deterioration assumptions to those used in the calculation of the Initial Health Score. It is derived by forecasting forwards from the Current Health Score using a simple exponential relationship as detailed in Section 6.1.10.

The rate of deterioration used for forecasting the Future Health Score is informed by the amount of deterioration in Asset Health that has already been observed for the asset from its current state (i.e. Current Health Score) and age. This is detailed in Section 6.1.8.

The Future Health Score is capped at a value of 15, which is higher than the cap that is applied to the Current Health Score. This is to enable modelling of further deterioration of all assets.

4.4.3 Future Probability of Failure

The calculation of future PoF uses the same relationship between Health Score and PoF that is used in the derivation of the current PoF (see Section 4.3.3 above).

The future PoF for an asset is derived by applying this relationship to the Future Health Score.

4.4.4 Interventions

The reporting of Health Index and Criticality Index requires the effect of investment activities that are aimed at managing the risk of condition-based failures to be evaluated. This is described in Section 6.1.11.

4.5 Evaluation of Consequences of Failure

The Methodology separately evaluates the CoF for each individual asset, in four specified Consequence Categories:-

i) Financial (incorporating repair & replacement costs);
ii) Safety;
iii) Environmental; and
iv) Network Performance.

A monetised value in £ (at 2012/13 prices) is assessed for each of these Consequence Categories. The Overall Consequence of Failure for an asset can therefore be derived by the summation of the CoF in each of these categories. These represent the impact of a failure and the societal cost of that impact.

The methodology for the calculation of CoF in each of the Consequence Categories is based on the use of Reference Costs of Failure. These are defined in Section 7 of the Methodology and are common, using accepted societal costs where available.

For an individual asset, the CoF associated with the asset is driven by the localised situation of the asset. For example, the Network Performance impact will be driven by the number of customers, or amount of load, that is affected by failure of the asset. Similarly, the environmental impact may be dependent on the proximity of the asset to an environmentally sensitive area (such as a watercourse).

To reflect this, the CoF associated with each individual asset is determined by application of asset-specific modifying factors to the appropriate reference cost. These factors represent the variation to the reference costs that results from the localised situation of the individual asset.

The Methodology specifies the asset-specific factors that shall be applied in the derivation of the CoF and also the associated calibration values. As a result, application of the Methodology results in a consistent evaluation of the CoF, across DNOs, which also reflects the localised situation of individual assets.

Section 7 provides details for the methodology for determining CoF. Worked examples of this calculation can be found in Appendix E.

4.6 Assimilating innovation in operation and maintenance

The Methodology has been designed such that it can seamlessly incorporate future innovation in operation and maintenance. Innovation in condition monitoring in particular has been a key driver in the development of health scores across electricity distribution over the last two decades. We envisage continual development and improvement in this field.

There are two key mechanisms that allow new developments to be assimilated:-

i) Much innovation consists of improving ways of understanding existing aspects of DNO assets better. Input factors have therefore been designed so that they are broad enough in description to allow the mapping of new techniques to existing factors. For example partial discharge is one of the measured Condition Modifiers in many Asset Categories, but how partial discharge is measured is non-prescribed. As better techniques are developed they can be used without requiring revision of the Methodology.

ii) Occasionally innovation might produce a new technology which would allow a brand new Condition Modifier to be used. In such an instance the change process described in SLC 51 Part I would be invoked to determine the appropriate weightings for inclusion of the new factor. The Methodology combines multiple Condition Inputs using an approach that ensures that such a change is easy to implement and also that it can be incorporated into the Methodology without causing knock-on effects on the existing set of Modifiers.

Another area of innovation is in the development of new interventions. The process of scoring assets post intervention is described in Appendix C to this document which is in turn governed under the RIGs Annex A [Ref. 1]. Subject to any change in the RIGs, the change process described in SLC 51 Part I would apply to enable instruction as to how the change should be applied to Health Scores.

5. RISK

5.1 Overview

This section covers the methodology which will be applied by DNOs in order to calculate the PoF and CoF of an asset, as well as the banding for mapping these outputs to the Health Index and Criticality Index within the Risk Matrix for each Asset Category.

5.2 Risk Evaluation

For each asset, the Methodology shall determine:-

i) the PoF (per annum); and
ii) the Overall CoF (£).

The risk of failure associated with each individual asset can be evaluated in £ (at 2012/13 prices) from the product of the PoF and the Overall Consequence of Failure values for that asset. However, the asset-specific actual risk of failure is not used for regulatory reporting. Instead a value of monetised risk, the Risk Index, is derived from the reported Health Index and Criticality Index for each asset. This is explained further in Section 5.3.

5.3 Risk Reporting

For the regulatory reporting of Asset Health and criticality, Risk Matrices are used. These show the population of assets within a given Asset Category that have the same Health Index and Criticality Index. This is illustrated in Figure 2.

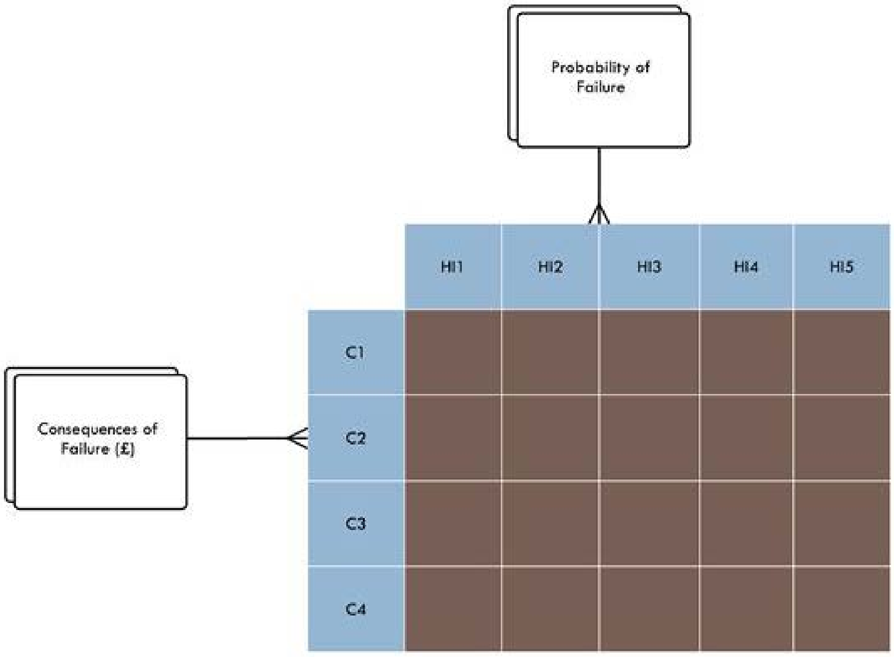

FIGURE 2: RISK REPORTING MATRICES

The Methodology evaluates the current health of an asset using a Health Score with a continuous scale between 0.5 and 10 (this scale is extended up to 15 for the forecasting of future health). The relationship between this Health Score and PoF is defined by the Methodology and is explained in Section 6. The Health Index subsequently groups assets into one of the five bandings (HI1 to HI5) based on their Health Score as shown in Table 5.

TABLE 5: HEALTH INDEX BANDING CRITERIA

Health Index Band	Health Index Banding Criteria	
	Lower Limit of Health Score	Upper Limit of Health Score
HI1	≥0.5	<4
HI2	≥4	<5.5
HI3	≥5.5	<6.5
HI4	≥6.5	<8
HI5	≥8	≤15

These Health Index Bands are subsequently translated to PoF values. The Health Index Band HI1 represents assets where the PoF is the same as that for a new asset. Figure 3 illustrates where the Health Index Bands lie on a typical Asset Health / PoF curve.

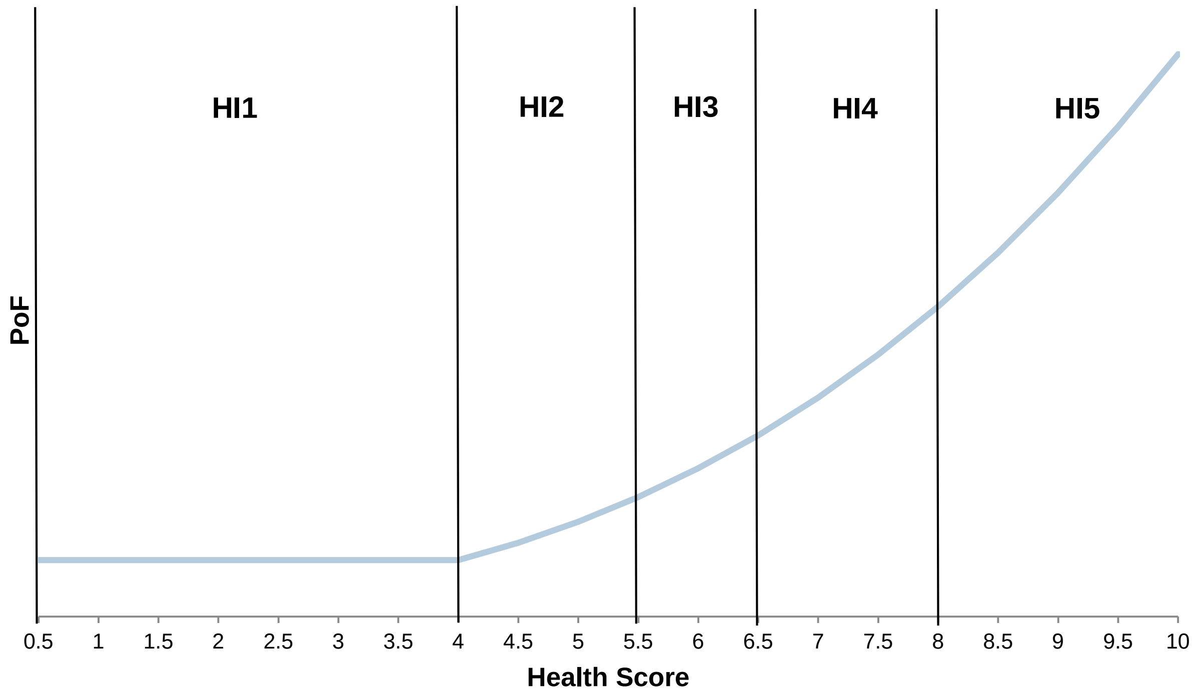

FIGURE 3: HI BANDING

By assigning:-

i) a typical value of PoF to all assets within the same Health Index Band (for a given Health Index Asset Category); and

ii) a typical value of Consequence of Failure to all assets within the same Criticality Index Band (for a given Health Index Asset Category)

it is possible for the risk associated with each asset to be approximated by reference to its position within the Risk Matrix. This provides the Risk Index used for regulatory reporting purposes. This is used to complete two requirements:-

i) The NAW, which stipulates the Secondary Deliverables a DNO has committed to deliver and remains fixed for the duration of RIIO-ED1, and

ii) The RIGs Annex D Secondary Deliverables workbook which provides the annual return on progress against the targets set out in the NAW.

Table 6 provides the input data for the typical PoF values.

TABLE 6: HEALTH SCORE USED TO DERIVE AVERAGE POF

Health Index Band	Health Score to be used to derive Average PoF
HI1	4
HI2	4.75
HI3	6
HI4	7.25
HI5	10

For the HI2 – HI4 bands, the use of the midpoint Health Score to derive the Average PoF produces a reasonable approximation of the average value that would be observed for a uniform distribution of assets within that Health Index Band.

The Criticality Index groups assets into bandings based on their CoF. Each asset shall be placed in a Criticality Index Band, based on the relative magnitude of the Overall CoF of the asset, compared to the Average Overall CoF for all assets in the same Health Index Asset Category.

There are four Criticality Index Bands:-

i) C1 - 'Low' criticality
ii) C2 - 'Average' criticality
iii) C3 - 'High' criticality
iv) C4 - 'Very High' criticality

The 'C2' Criticality Index Band represents assets where the Overall CoF are approximately the same as the Average Overall CoF for all assets within a DNO in the same Health Index Asset Category.

For each Asset Category, the Criticality Index Banding Criteria are expressed as a percentage of the Average Overall CoF for all assets in the same Health Index Asset Category. These are shown in Table 7.

TABLE 7: CRITICALITY INDEX BANDING CRITERIA

Criticality Index Band	Criticality Index Banding Criteria		Value to be used to calculate Risk Index (stipulated in the NAW)
	Lower Limit of Overall CoF (as % of Average Overall CoF for the Asset Category)	Upper Limit of Overall CoF (as % of Average Overall CoF for the Asset Category)	
C1	-	< 75%	70%
C2	≥ 75%	< 125%	100%
C3	≥ 125%	< 200%	150%
C4	≥ 200%	-	250%

For regulatory reporting, DNOs are required to report the Average Overall CoF for each Health Index Asset Category used when allocating assets into the appropriate Criticality Index Band. These are values that represent the average for the individual DNO.

The values for Average Overall CoF are calculated from the asset population that exists in a reference year, defined in the regulatory reporting requirements. These values are then fixed, as reference values, for the allocation of assets into Criticality Index Bands in subsequent years. The typical values of CoF by Criticality Index Band used to multiply out the Risk Matrices are given in the NAW and included for completeness in Table 7 above. The Health Index and Criticality Index information is consequently used to derive the Risk Index (monetised risk).

Using the approach outlined above, the outputs from the Methodology facilitate population of Risk Matrices representing the following three scenarios:-

i) existing asset risk;
ii) future asset risk; and
iii) future asset risk taking account of planned interventions.

This information shall be used for the regulatory reporting of the Health Index and Criticality Index for each asset as shown in Figure 4. The monetisation of risk is consistent across all Asset Categories and therefore enables risk trading within and across Asset Categories.

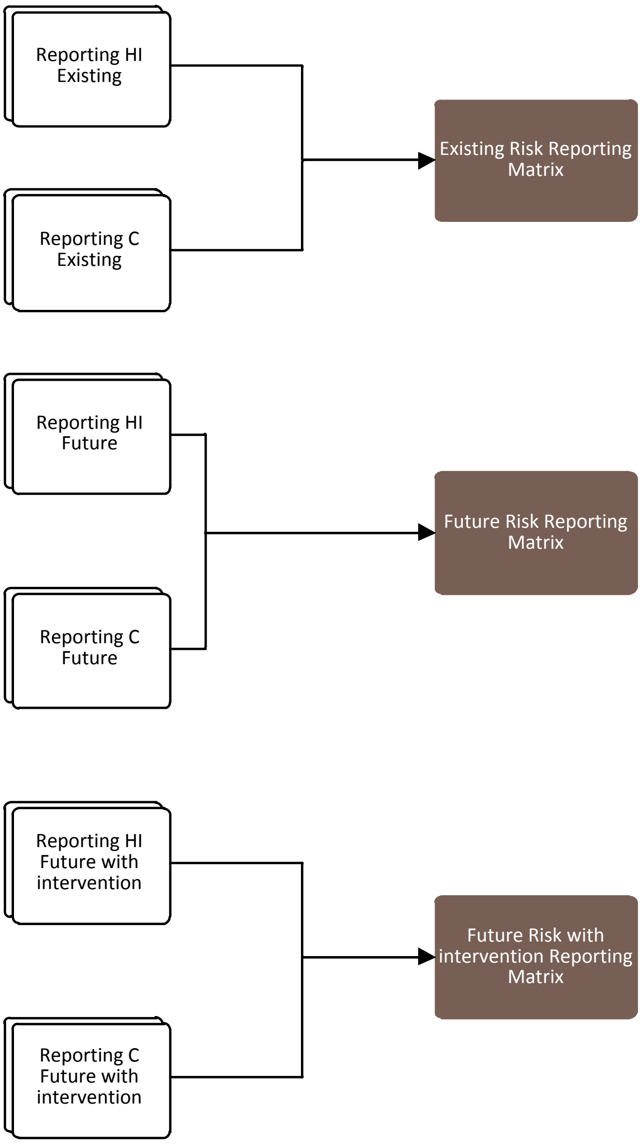

FIGURE 4: REPORTING OF RISK FOR EACH SCENARIO

6. PROBABILITY OF FAILURE

6.1 PoF Calculation (General)

6.1.1 Overview

The Health Index (HI) is derived from the Health Score and PoF. The PoF of an asset is a function of the asset's Health Score, with the Health Score being a function of Normal Expected Life, location, duty, reliability, observed condition and measured condition.

For the majority of assets a single Health Score is calculated, which is then converted into a PoF. However for EHV and 132kV Transformers and steel Towers it is necessary to calculate a Health Score for each component and then combine these into an overall Health Score. These multi-component assets are special cases which are covered in more detail in Sections 6.2 and 6.3. Figure 5 shows the process to be followed in order to calculate the PoF of an asset (or component):-

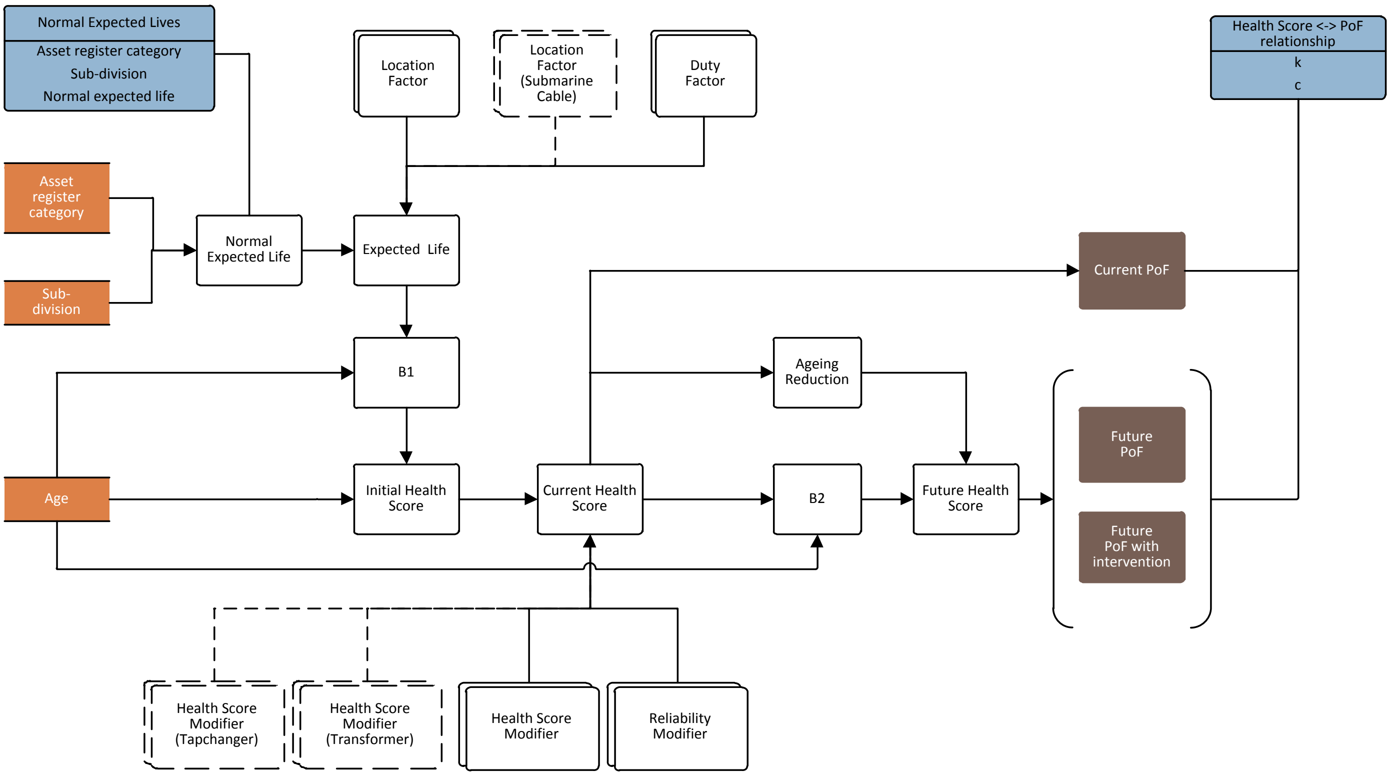

FIGURE 5: PROBABILITY OF FAILURE

The PoF per annum shall be calculated using the cubic curve shown in Eq. 1. This is based on the first three terms of the Taylor series for an exponential function. This implementation has the benefit of being able to describe a situation where the PoF rises more rapidly as asset health degrades, but at a more controlled rate than a full exponential function would describe.

$$\mathrm{PoF} = \mathrm{K} \times \left[1 + (\mathrm{C} \times \mathrm{H}) + \frac{(\mathrm{C} \times \mathrm{H})^2}{2!} + \frac{(\mathrm{C} \times \mathrm{H})^3}{3!}\right] \qquad \text{(Eq. 1)}$$

Where:

- *H is a variable equal to Health Score (Current or Future), unless Health Score ≤ 4 then H = 4*
- *K and C are constants*

The constants and variables in the above equation are described in Section 6.1.2.

6.1.2 K-Value, C-Value and Constants in PoF

A generic and common PoF curve as described by Eq. 1 is used to define the relationship between asset Health Score and PoF. The curve is one commonly used in reliability theory. It shows constant PoF for low values of Health Score and an exponential increase in PoF for higher values of Health Score, representing where increasing health degradation results in an escalating likelihood of failure. The shape of a typical PoF curve can be seen in Figure 3.

For a common curve, the parameters used to construct the curve need to be common. The common parameters are the C-Value that defines the shape of the curve, the K-Value that scales the PoF to a failure rate, and the Health Score limit at which there is a transition from constant PoF to an exponential relationship. The values for the C-Values, the K-Values and the constant Health Score limit are shown in Table 21 in Appendix B.

The C-Value is the same for all Asset Categories and has been selected such that the PoF for an asset in the worst state of health is ten times higher than the PoF of a new asset.

The Health Score limit represents the point at which there starts to be a direct relationship between the Health Score and an increasing PoF. The PoF associated with Health Scores below this limit relate to installation issues or random events.

The K-Value for each Asset Category has been derived by consideration of:-

i) the observed number of Functional Failures per annum, taking into account the number of failures in each of the three failure modes that are identified in Appendix A (i.e. Incipient Failures, Degraded Failures and Catastrophic Failures for each Asset Category);
ii) the Health Index distribution for the asset population; and
iii) volumes of assets within the population.

By calibrating K using the overall number of Functional Failures across all the failure modes, the resulting PoF represents the combined PoF for all considered failure modes.

The calibration of K has been undertaken using data representing the national population of assets and ensures that in each Asset Category the total GB expected number of Functional Failures, derived from the relative PoF contribution of every asset in the GB Health Index distribution, matches the number of GB Functional Failures.

For linear assets (Cables and Tower Conductor) the K-Value was calculated using the GB number of Functional Failures per kilometre per annum. The PoF reported for these Asset Categories is therefore the PoF per km per annum. The number of kilometres reported per Health Index Band is the sum of the length of the assets falling within that band.

The national failure rate figures used were the sum of all DNO functional failures (five year annualised average) in accordance with the Condition-based Functional Failure definition. These are shown in Appendix A.

6.1.3 Normal Expected Life

The Normal Expected Life depends on the Asset Register Category and its sub-category. It is defined as the time (in years) in an asset's life when the first significant signs of deterioration would be expected. This corresponds to a Health Score of 5.5. The value is specified in the Normal Expected Lives calibration table (Table 20, Appendix B) and is expressed in years.

6.1.4 Expected Life

Expected Life is derived from Normal Expected Life, taking into account two degradation factors: Location Factor (which represents the effects of the surrounding environment on the asset) and Duty Factor (which represents any additional ageing due to the way in which the asset is being used). Expected Life is calculated using Eq. 2.

$$\text{Expected Life} = \frac{\text{Normal Expected Life}}{(\text{Duty Factor} \times \text{Location Factor})} \qquad \text{(Eq. 2)}$$

Location and Duty Factors are described in more detail in Sections 6.4 - 6.6.

6.1.5 β_1 (Initial Ageing Rate)

The rate of change of the health of a distribution asset is modelled exponentially, as it is assumed that the processes involved as the asset deteriorates (e.g. corrosion, oil oxidation, insulation breakdown, etc.) are accelerated by the products of the deterioration process.

The Ageing Rate of the asset is determined from the natural logarithm of the asset's Health Score when new and the Health Score that corresponds to the Expected Life of the asset, using Eq. 3.

$$\beta_1 = \frac{\ln\left(\frac{H_{\text{expected life}}}{H_{\text{new}}}\right)}{\text{Expected Life}} \qquad \text{(Eq. 3)}$$

Where:

- *H_{new} is the Health Score of a new asset, equal to 0.5*
- *$H_{Expected\ Life}$ is the Health Score of the asset when it reaches its Expected Life, equal to 5.5*
- *Expected Life is described in Section 6.1.4*

6.1.6 Initial Health Score

The Initial Health Score is obtained by defining the generic relationship between Asset Health and age using the Expected Life of the asset.

$$\text{Initial Health Score} = H_{\text{new}} \times e^{(\beta_1 \times \text{age})} \qquad \text{(Eq. 4)}$$

Where:

- *H_{new} is the Health Score of a new asset, equal to 0.5*
- *Initial Health Score is capped at a value of 5.5*
- *β_1 is the initial Ageing Rate as described is Section 6.1.5*
- *age is the current age of the asset in years*

This relationship gives an initial estimate of Asset Health, but does not take into account any actual health measurement or assessment that may have been carried out. This stage provides an initial age-based indication of health up to a maximum Health Score of 5.5, which needs to be modified in the next stage to take account of available data regarding the health of the asset.

6.1.7 Current Health Score

The Initial Health Score is modified according to available data using the Health Score Modifier and, where appropriate, a Reliability Modifier (see Section 6.14).

The Health Score Modifier consists of three components:-

i) Health Score Factor, which determines how the Initial Health Score is to be modified;
ii) Health Score Cap, which specifies the maximum value of Current Health Score (used in situations where a good result from a condition inspection or measurement implies that the Health Score should be no more than the specified value); and
iii) Health Score Collar, which specifies the minimum value of Current Health Score (used in situations where a poor result from a condition inspection or measurement implies that the Health Score should be at least the specified value).

The Reliability Modifier may consist of two components:-

i) A Reliability Factor; and
ii) A Reliability Collar.

The Current Health Score is calculated initially as follows:-

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor} \quad \text{(Eq. 5)}$$

The Current Health Score is then compared with Health Score Cap as follows:-

$$\begin{array}{l}\textbf{IF } \text{Current Health Score} > \text{Health Score Cap} \\ \textbf{THEN } \text{Current Health Score} = \text{Health Score Cap}\end{array} \quad \text{(Eq. 6)}$$

Where:

- *Current Health Score is capped at 10*

The Current Health Score is then compared with Health Score Collar as follows:-

$$\begin{array}{l}\textbf{IF } \text{Current Health Score} < \text{MAX (Health Score Collar, Reliability Collar)} \\ \textbf{THEN } \text{Current Health Score} = \text{MAX (Health Score Collar, Reliability Collar)}\end{array} \quad \text{(Eq. 7)}$$

Note that the order of calculation is important; the calculation must be done in the order specified to ensure that poor condition measurements override good ones; i.e. the Current Health Score must be compared with the Health Score Cap and assigned a result before comparing this result to the Health Score Collar.

Typically, the Health Score Collar is 0.5 and Health Score Cap is 10, implying no overriding of the Health Score. However, in some instances these parameters are set to other values in the

Health Score Modifier calibration tables. These overriding values are shown in Table 34 to Table 195 and Table 200 in Appendix B.

6.1.8 β_2 (Forecast Ageing Rate)

In order to forecast a Future Health Score from the Current Health Score, the Ageing Rate needs to be re-calculated so that the effects of the Health Score Modifier and Reliability Modifier are taken into account. This is undertaken so that the forecast ageing reflects the Ageing Rate implied by the asset's actual condition. For assets where no ageing has been observed (i.e. the Current Health Score is 0.5) no re-calculation of the Ageing Rate is performed.

The Forecast Ageing Rate β_2 is derived from the Current Health Score and the current age of the asset using Eq. 8 when the Current Health Score > 0.5. Where the Current Health Score = 0.5, $\beta_2 = \beta_1$.

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}} \quad \text{(Eq. 8)}$$

Where:

- *Age is the current age of the asset (i.e. the age used in the calculation of the Initial Health Score)*
- β_2 *is capped such that:-*

$$\beta_2 \leq 2 \times \beta_1 \quad \text{(Eq. 9)}$$

β_2 is capped to prevent unrealistically high rates of deterioration being applied to relatively new assets where reliability issues have been identified early on in their life.

6.1.9 Ageing Reduction Factor

The use of the exponential curve results in an escalating acceleration effect once assets reach a high Health Score. For assets that are approaching end of life (EoL), this can result in a run-away effect in the forecast future PoF, which would not reflect the deterioration that would be observed in real life.

The cause of the runaway effect is due to the imperfect match of the selected curve once the asset reaches high values of health and hence resultant PoF. In order to minimise the potential for overstatement of the forecast future PoF, an Ageing Reduction Factor is introduced to modify the asset's rate of deterioration. This slows down the Ageing Rate of the asset by flattening the exponential curve especially (although not exclusively) where the Health Score is greater than 5.5.
In young assets of unproven reliability there may be a higher PoF when compared to assets of a higher age. Therefore, as an asset has reached the higher age with no identified issues, the probability is that it will continue to provide good service and hence its life expectancy is longer than the younger asset. Therefore the old asset's PoF can be reduced in relative terms from the value calculated.

The ageing reduction technique as described above is used to reduce the forecast increase in PoF with time for assets where the Current Health Score represents any significant level of degradation. The ageing reduction factor acts by reducing the original ageing factor. This practice is in keeping with the common use by engineers of P-F interval reliability concepts [Ref. 2] which set:-

i) P as the point where a potential failure can be detected; and
ii) F as where the functional failure occurs.

In such concepts, a curve is drawn between the two points, P and F, to produce a forecast of time to failure and the reduction effect is capped so that the accelerated ageing that occurs as the asset approaches failure is correctly reflected.

In the Methodology, the Ageing Reduction Factor applied will vary, depending on the Current Health Score for the asset:-

i) for assets where the Current Health Score is greater than 5.5, the Ageing Reduction Factor is set to its maximum permissible value; and
ii) for assets where the Current Health Score is less than 2, the Ageing Reduction Factor is set to unity.

In order to prevent low Health Score assets deteriorating more quickly than high Health Score assets when forecasting, there must be no significant step change in the factor value. The Ageing Reduction Factor therefore varies linearly between unity and its maximum permissible value, for Health Scores between 2 and 5.5.

The maximum permissible value of the Ageing Reduction Factor is set to 1.5.

The Ageing Reduction Factor calibration table can be seen in Table 209 in Appendix B and is illustrated in Figure 6.

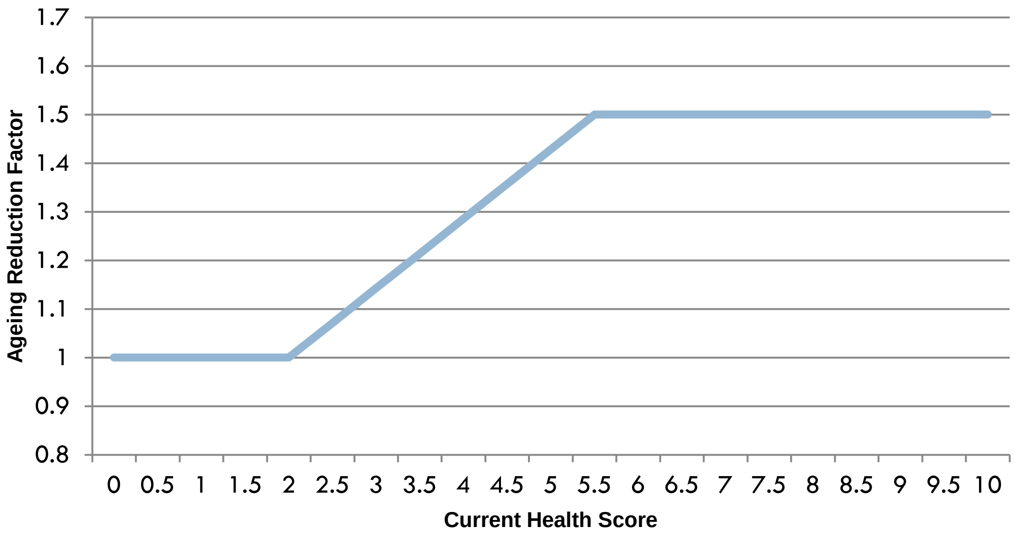

FIGURE 6: AGEING REDUCTION FACTOR

The effects of the changes to the ageing assumptions that arise from re-calculation of the Ageing Rate for forecasting future health (as described in Section 6.1.8) and the application of an Ageing Reduction Factor are shown in Figure 7. This shows three deterioration curves based on:-

i) the initial Ageing Rate, β_1;

ii) the "trued-up" Ageing Rate which would have been necessary for the asset to be in its current condition; and

iii) the application of an Ageing Reduction Factor.

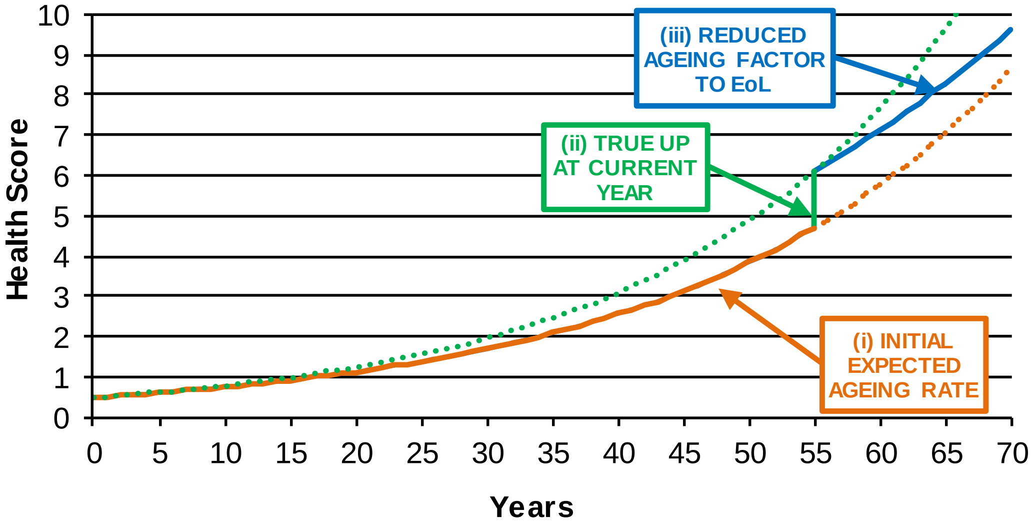

FIGURE 7: EFFECT OF AGEING REDUCTION FACTOR ON ASSET DETERIORATION

6.1.10 Future Health Score - Deterioration

The Future Health Score is calculated using the same exponential based methodology as the Initial Health Score.

$$\text{Future Health Score} = \text{Current Health Score} \times e^{((\beta_2/r) \times t)} \quad \text{(Eq. 10)}$$

Where:

- *t is the number of future years;*
- *Current Health Score is as described in Section 6.1.7;*
- *β_2 is the Forecast Ageing Rate as described in Section 6.1.8;*
- *r is the Ageing Reduction Factor as described in Section 6.1.9; and*
- *Future Health Score is capped at 15.*

6.1.11 Interventions

Interventions are activities that are undertaken to manage the risk of condition-based failure. In RIIO-ED1, DNOs have Network Asset Secondary Deliverables that relate to the improvement in risk that is delivered by Asset Replacement, as well as some Refurbishment activities. Such activities are primarily aimed at managing risk by reducing the PoF.

The effect of these activities is calculated by modifying the input data used in the Methodology. This approach shall be used for the calculation of either the Current Health Score or Future Health Score.

For Asset Replacement interventions, this is simply a recalculation of Asset Health and Criticality (and hence risk) taking account of the changes in the asset population that have resulted from the Intervention (i.e. removal of assets and the addition of new assets).

For Refurbishment interventions, the Asset Health and Criticality are recalculated using revised input data for the asset that is subject to the Refurbishment activity. This revised input data should take account of the change in input data that has resulted from the Refurbishment activity e.g. changes to the Health Score Modifier to reflect the observed or measured condition following completion of the Refurbishment.

Only certain Refurbishment activities contribute to the delivery of the Network Asset Secondary Deliverables. These are defined in Ofgem's RIIO-ED1 Regulatory Instructions and Guidance – Annex A.

Appendix C identifies these Refurbishment activities and also the input data that should be re-evaluated in order to account for the improvement in risk delivered by such activity.

6.2 PoF Calculation (EHV and 132kV Transformers)

The PoF for EHV Transformers (33kV & 66kV Transformers) and 132kV Transformers is derived by separate consideration of the health of two distinct subcomponents:-

i) the main transformer; and
ii) the tapchanger.

This recognises the degree of independence between the health of these components.

The Health Score for the overall transformer asset is derived from the combination of the Health Scores for both of these components.

Health Scores for the main transformer and tapchanger components are separately determined, using broadly the same approach as outlined in Section 6.1. This is summarised below:-

i) A separate Initial Health Score is calculated for the main transformer subcomponent and the tapchanger subcomponent, using Eq. 4, as described in Section 6.1.6. For each component different Normal Expected Lives and age information shall be used. However, the same Location Factor is applied to both the main transformer and the tapchanger but they each have a different duty factor. The Normal Expected Life of the tapchanger subcomponent and main transformer subcomponent are shown in Table 20 in Appendix B.

   To calculate the Initial Health Scores using Eq. 4:-

   - for the main transformer the Normal Expected Life for a transformer is used and the age is taken as being the age of the main transformer component;

- for the tapchanger the Normal Expected Life for a tapchanger is used and the age is taken as being the age of the tapchanger component.

Where the age of the tapchanger and the age of the main transformer component are not separately known, it is assumed that both components have the age that is recorded for the overall transformer asset.

ii) Separate Health Score Modifiers are calculated for both the main transformer and the tapchanger components. The calculation of these Health Score Modifiers is discussed in Section 6.8.

For both the main transformer and tapchanger components, the Health Score Modifier is derived using an Observed Condition Modifier, a Measured Condition Modifier and an Oil Test Modifier. The determination of these Modifiers is described in Sections 6.9, 6.10, 6.11.

For the main transformer subcomponent a DGA Test Modifier and FFA Test Modifier are also used in addition to the Observed Condition Modifier, Measured Condition Modifier and Oil Test Modifier. These additional Modifiers are described in Sections 6.12 and 6.13

iii) Separate Current Health Scores are calculated for both components using the Health Score Modifier and the Initial Health Score calculated for the relevant component, e.g. the Health Score Modifier for the tapchanger component is applied to the Initial Health Score for the tapchanger component in order to calculate the Current Health Score for the tapchanger component.

iv) A forecast Ageing Rate, β_2, is separately calculated for each component, using the approach described in Section 6.1.8. For each component, the age used in the calculation of β_2 is the same age that was used in the calculation of the Initial Health Score.

v) The Future Health Score is calculated for each component using Eq. 10, as described in Section 6.1.10. For each component the Current Health Score and value of β_2, relating to that component, is used in the determination of the Future Health Score.

The Current Health Score of the overall transformer asset is taken as the maximum of the Current Health Score of the main transformer component and the Current Health Score of the tapchanger component.

Similarly, the Future Health Score of the overall transformer asset is taken as the maximum of the Future Health Score of the main transformer component and the Future Health Score of the tapchanger component.

The PoF for the overall transformer asset is determined by application of Eq. 1 (Section 6.1.1) to the overall Health Score (i.e. the maximum Health Score of the subcomponents).

6.3 PoF Calculation (Steel Towers)

Steel Towers are made up of individual steel members bolted together to form a lattice arrangement above ground. Tower foundations are the interlinking component between the support and the ground (soil and/or rock).

The life of a steel Tower is primarily dependent on the rate of deterioration of this steelwork both above and below ground.

New steelwork is protected from corrosion by zinc galvanising. Under normal circumstances galvanising would be expected to provide protection against the onset of corrosion, for the steelwork above ground, for a period of up to 30 years.

A paint system would normally be applied to the steelwork above ground, in order to provide a secondary form of protection against corrosion. The paintwork, itself, will deteriorate over time (typically providing protection for up to 20 years) and will require reapplication in order to maintain its protective function. The first application of a paint system to a Tower normally takes place after 30 years, once the zinc galvanising has expired.

For Towers, once corrosion has set in the intervention requirement changes considerably from low cost piecemeal steel member replacement and the application of a protective paint system, to much more expensive full Tower replacement. Therefore with regards to the above ground steelwork, the typical strategy adopted by DNOs is to paint/refurbish before significant corrosion sets in. The typical effect of such a strategy on the Health Score of a Tower, through its life, is illustrated in Figure 8.

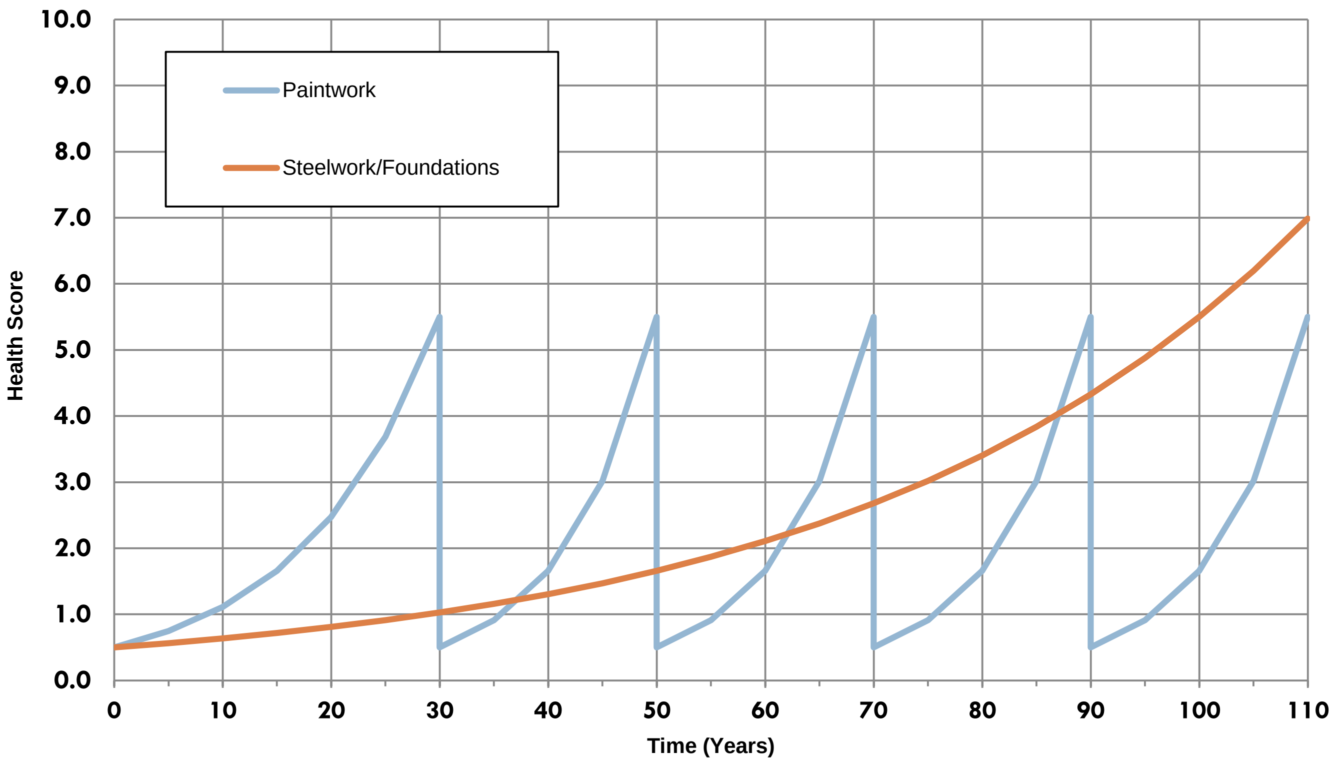

FIGURE 8: STEEL TOWER HEALTH SCORE

Therefore within this framework the overall life cycle (Health Score) for a steel Tower is defined as a function of three discrete elements of the Tower:-

i) the paintwork;
ii) the steelwork; and
iii) the foundations.

Health Scores for each of these three components are separately determined, using broadly the same approach as outlined in Section 6.1. This is summarised below:-

i) A separate Initial Health Score is calculated for each of the three components, using Eq. 4, as described in Section 6.1.6. For each component different Normal Expected Lives and age information shall be used. However, the same Location and Duty Factors are applied to all three components. The Normal Expected Life of the paint system (rather than the Tower), foundations and steelwork are shown in Table 20 in Appendix B. To calculate the Initial Health Scores using Eq. 4:-
   - for the Tower steelwork: the Normal Expected Life of steelwork shall be used[1];
   - for the paintwork:
     - if the Tower is unpainted: the Normal Expected Life of the galvanising is used and the age is taken as being the age of the Tower steelwork;
     - if the Tower is painted: the Normal Expected Life of paint is used and the age is taken as time that has elapsed since the Tower was last painted;
   - for the Tower foundation: the Normal Expected Life of the Tower foundation is used and the age is taken as being the age of the foundation.

   Where the age of the Tower steelwork and the age of the Tower foundation are not separately known, it is assumed that both the steelwork and foundation have the age that is recorded for the overall Tower.

ii) Separate Health Score Modifiers are calculated for each of the three components.

iii) Separate Current Health Scores are calculated for each of the three components using the Health Score Modifier and the Initial Health Score calculated for the relevant component, e.g. the Health Score Modifier for the paintwork component is applied to the Initial Health Score for the paintwork component in order to calculate the Current Health Score for the paintwork component. The Current Health Score for the paintwork component is capped at 6.4 to reflect the limited effect of paintwork, alone, on the overall health of a tower.

iv) A forecast Ageing Rate, β_2 is separately calculated for each of the three components, using the approach described in Section 6.1.8. For each component, the age used in the calculation of β_2 is the same age that was used in the calculation of the Initial Health Score.

v) A Future Health Score is calculated for each of the three components using Eq. 10, as described in Section 6.1.10. For each component the Current Health Score and value of β_2, relating to that component, shall be used in the determination of the

[1] The primary age of the Tower steelwork will be that of the Tower itself, accepting that some of the steelwork may have been replaced piecemeal in later years.

Future Health Score. The Future Health Score for the paintwork component is capped at 6.4 to reflect the limited effect of paintwork, alone, on the overall health of a tower.

The Current Health Score of the Tower is taken as the maximum of the Current Health Score of the steelwork, the Current Health Score of the paintwork and the Current Health Score of the foundations. As Paintwork condition on its own does not instigate replacement of a steel tower, a cap of 6.4 is applied to the Current Health Score of the paintwork component (as described in (iii) above). This has been done to match the impact and importance of the paintwork condition on the overall score of a Tower to reality.

Similarly, the Future Health Score of the Tower is taken as the maximum of the Future Health Score of the steelwork, the Future Health Score of the paintwork and the Future Health Score of the foundations. Again, the effect of the paintwork component upon the Future Health Score of the Tower is limited by application of a cap on the value of the Future Health Score of the paintwork (as described in (v) above).

The PoF for the overall Tower is determined by application of Eq. 1 (Section 6.1.1) to the overall Health Score (i.e. the maximum Health Score across the three subcomponents).

6.4 Location Factor (General)

6.4.1 Overview

The Expected Life of an asset is affected by the environment in which the asset is installed. For example, assets exposed to higher levels of moisture or pollution may be expected to degrade quicker than assets of the same type exposed to lower levels of moisture or pollution. The levels of exposure will depend on the location of the asset and also whether or not it is installed within an enclosure that affords protection from the weather.

This effect is recognised by the use of an asset-specific Location Factor in the determination of the Expected Life for individual assets. For all Asset Categories, except LV UGB and Cable, this Factor is influenced by:-

i) distance from coast;
ii) altitude;
iii) corrosion category; and
iv) environment (indoor / outdoor).

Where it is not known whether an asset is located indoor or outdoor, a default assumption based on the Asset Register Category shall be applied as per Table 25A in Appendix B.

Different factors are considered in the derivation of an asset-specific Location Factor for submarine cable assets. These are explained in Section 6.5.

For LV UGB assets and all non-submarine cable assets (i.e. cables installed on land), a Location Factor of 1 is assigned to all assets.

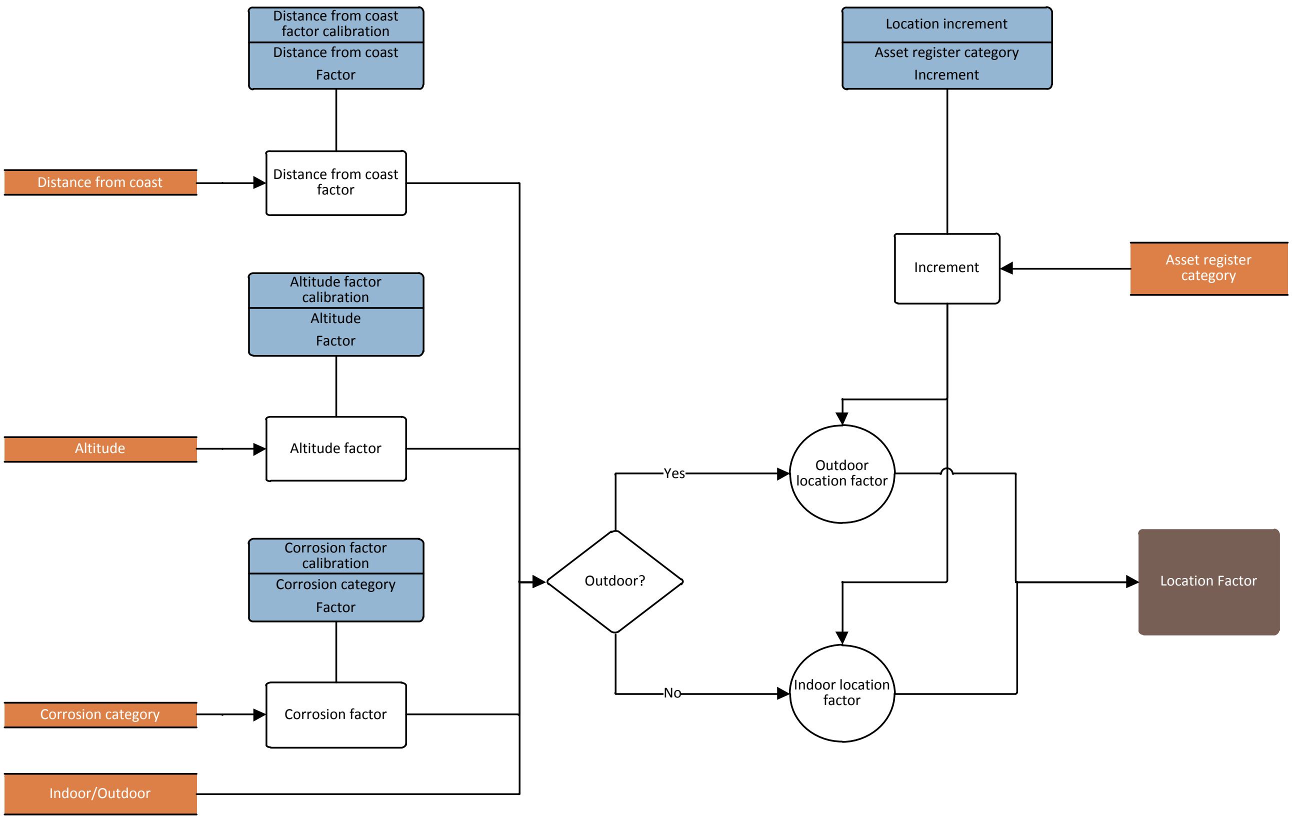

FIGURE 9: LOCATION FACTOR

6.4.2 Distance from Coast Factor

The Distance from Coast Factor is determined based on the distance of the asset (or its substation location) from the coast, measured in km. The Distance from Coast Factor is applied as shown in Table 22 in Appendix B.

6.4.3 Altitude Factor

An Altitude Factor is determined based on the altitude of the asset (or its substation location, measured in metres). The derivation of Altitude Factor is based on a look up table using bandings of altitude. The Altitude Factor is applied as shown in Table 23 in Appendix B.

6.4.4 Corrosion Factor

A Corrosion Factor is determined based on the Corrosion Category Index (1-5) for the location of the asset. The Corrosion Factor is applied as shown in Table 24 in Appendix B.

6.4.5 Determining the Location Factor for assets in an outdoor environment

Where an asset is installed in an outdoor environment, the Location Factor is determined as follows:-

i) If the maximum of the Distance From Coast Factor, Altitude Factor and Corrosion Factor is greater than 1:-

$$\text{Location Factor} = \text{MAX}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor}) + \left(\left((\text{COUNT of factors greater than 1}) - 1\right) \times \text{INC}\right) \quad \text{(Eq. 11)}$$

Where:

- *INC is the increment constant for the asset type (shown in Table 25)*

ii) If the maximum of the Distance From Coast Factor, Altitude Factor and Corrosion Factor is not greater than 1:-

$$\text{Location Factor} = \text{MIN}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor}) \quad \text{(Eq. 12)}$$

6.4.6 Determining the Location Factor for assets in an indoor environment

Where an asset is installed in an indoor environment, the Location Factor is determined as follows:-

i) If the maximum of the Distance From Coast Factor, Altitude Factor and Corrosion Factor is greater than 1:-

$$\text{Initial Location Factor} = \text{MAX}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor}) + \left(\left((\text{COUNT of factors greater than } 1) - 1\right) \times \text{INC}\right) \quad \text{(Eq. 13)}$$

Where:

- *INC is the increment constant for the asset type (shown in Table 25)*

ii) If the maximum of the Distance From Coast Factor, Altitude Factor and Corrosion Factor is not greater than 1:-

$$\text{Initial Location Factor} = \text{MIN}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor}) \quad \text{(Eq. 14)}$$

iii) Steps (i) and (ii) are the same as for an asset in an outdoor environment. This additional step recognises the shielding effect of the indoor environment on the asset in question. The Location Factor is calculated from the Initial Location Factor using Eq. 15.

$$\text{Location Factor} = 0.25 \times (\text{Initial Location Factor} - \text{Minimum Initial Location Factor}) + \text{Minimum Initial Location Factor} \quad \text{(Eq. 15)}$$

Where:

- *Minimum Initial Location Factor is the value of Initial Location Factor that would be determined if all location factors (i.e. Distance From Coast Factor, Altitude Factor and Corrosion Factor) were at their minimum possible value for the asset type, from the calibration Tables 22 to 24.*

6.5 Location Factor (Submarine Cables)

6.5.1 Overview

The Location Factor for Submarine Cable is made up of four factor inputs:-

i) Submarine Cable Route Topography Factor;
ii) Situation Factor;
iii) Wind/Wave Factor; and
iv) Combined Wave & Current Energy Factor.

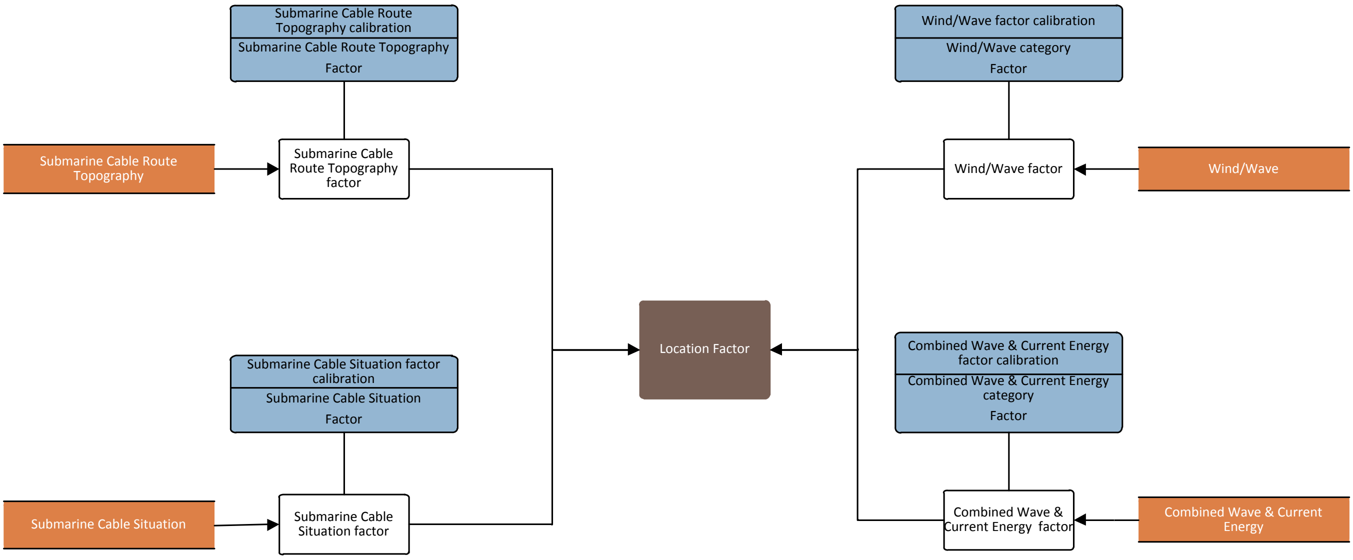

FIGURE 10: LOCATION FACTOR - SUBMARINE CABLES

6.5.2 Submarine Cable Route Topography Factor

The route topography factor considers the nature of the cable route in which the submarine cable has been laid. This considers the seabed makeup, landscape and the potential for cable to be suspended above the seabed.

The value for this factor is applied as shown in Table 26 in Appendix B.

6.5.3 Submarine Cable Situation Factor

The Submarine Cable Situation factor takes into account its installed situation: laid on bed, covered and buried.

The value for this factor is applied as shown in Table 27 in Appendix B.

6.5.4 Wind/Wave Factor

The wind and wave environment that submarine cables are subjected to has been identified as directly affecting the severity of mechanical movement (action) on the shore ends. This is captured by the wind/wave factor.

The value for this factor is applied as shown in Table 28 in Appendix B.

6.5.5 Combined Wave & Current Energy Factor

The rate at which fretting (abrasion of the cable armour) takes place is heavily dependent on the amount of energy exerted on both the cable and the seabed due to waves, tidal currents, or their combined effects. The combined wave and current energy factor takes this into account.

The value for this factor is applied as shown in Table 29 in Appendix B.

6.5.6 Determining the Location Factor for Submarine Cables

If the maximum of the Submarine Cable Route Topography Factor, Situation Factor, Wind/Wave Factor, Combined Wave & Current Energy Factor is greater than 1:-

$$\begin{aligned}&\textbf{Location Factor}\\&= \textbf{MAX}(\textbf{Submarine Cable Route Topography Factor}, \textbf{Situation Factor}, \textbf{Wind}\\&/\textbf{Wave Factor}, \textbf{Combined Wave \& Current Energy Factor})\\&+ \Big(\big((\textbf{COUNT of factors greater than 1}) - 1\big) \times \textbf{INC}\Big)\end{aligned}$$ (Eq. 16)

Where:

- *INC is the increment constant for the asset type (Table 25, Appendix B)*

If the maximum of the Submarine Cable Route Topography Factor, Situation Factor, Wind/Wave Factor, Combined Wave & Current Energy Factor is not greater than 1:-

$$\begin{aligned}&\textbf{Location Factor}\\&= \textbf{MIN}(\textbf{Submarine Cable Route Topography Factor}, \textbf{Situation Factor}, \textbf{Wind}\\&/\textbf{Wave Factor}, \textbf{Combined Wave \& Current Energy Factor})\end{aligned}$$ (Eq. 17)

6.6 Duty Factor

The Expected Life of an asset varies depending on the duty to which it is subjected.

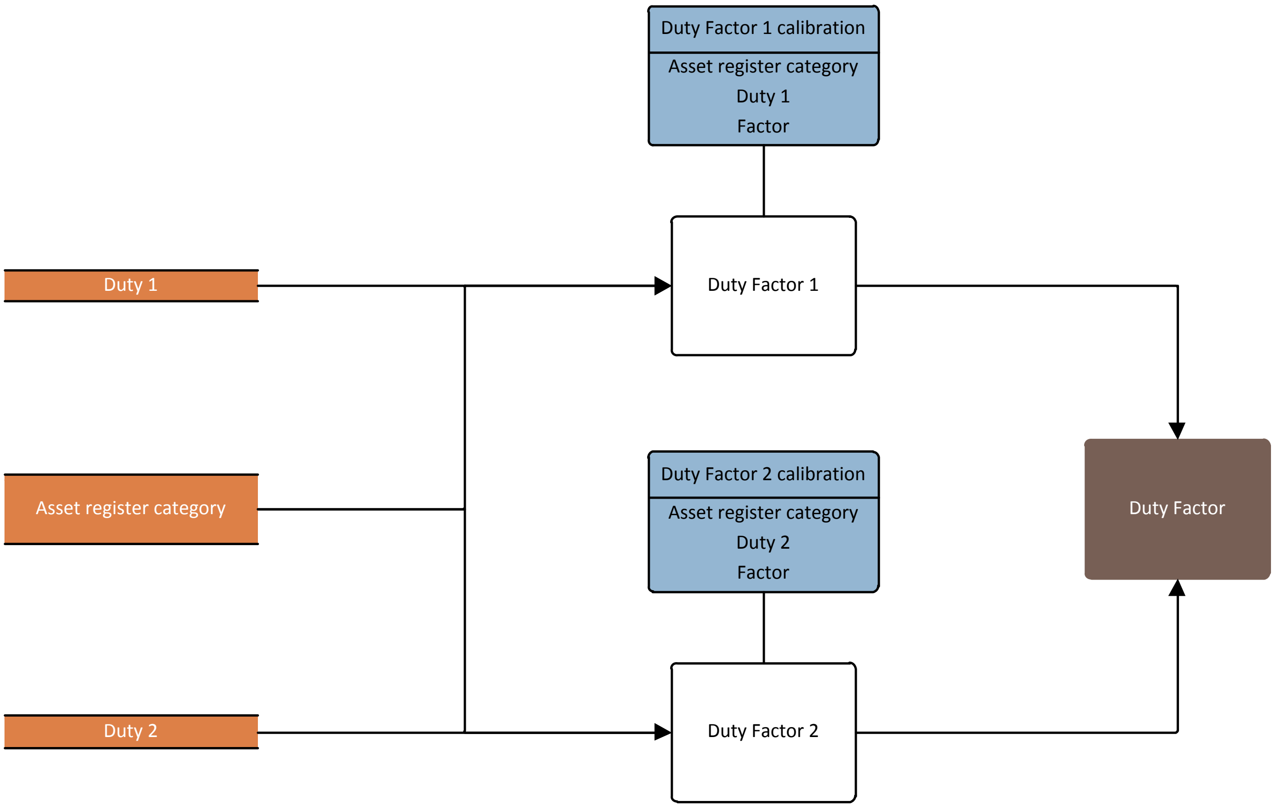

FIGURE 11: DUTY FACTOR

For electrical assets, the duty factor is a function of loading, number of operations, design voltage and operating voltage. Table 8 shows how these factors are to be applied to the different Asset Categories:

TABLE 8: DUTY FACTOR METHODOLOGY

Asset Category	Duty Factor 1 (DF1)	Duty Factor 2 (DF2)
Cables	% Utilisation	Operating Voltage ÷ Design Voltage
Poles	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
LV UGB	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Switchgear - LV	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Switchgear - HV Distribution	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Switchgear - HV Primary	Number of Operations	N/A
Switchgear - EHV & 132kV		
Steel Tower	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Conductor	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Fittings	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
HV Transformer (GM)	% Utilisation	N/A
Transformers - EHV & 132kV	Transformer: % Utilisation	N/A
	Tapchanger: Average Number of Daily Tapping Operations	N/A

Where there is only a single Duty Factor, then:-

$$\text{Duty Factor} = \text{DF1}$$ (Eq. 18)

Where two Factors are combined to create the Duty Factor, then:-

$$\text{Duty Factor} = 0.5 \times \text{DF1} + 0.5 \times \text{DF2}$$ (Eq. 19)

The Duty Factor lookup tables which are applied to the respective Asset Categories are shown in Table 30 to Table 33.

6.7 Health Score Modifier

6.7.1 Overview

Asset-specific Health Score Modifiers are calculated for each individual asset. The Health Score Modifier is determined from observed condition and measurement results. The Health Score Modifier is used to inform the Current Health Score, such that it reflects the observed health of the asset.

For all Health Index Asset Categories, with the exception of EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers, a single Health Score Modifier is calculated for each asset. The calculation of Health Score for assets in the EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers Asset Categories requires separate evaluation of the Health Score for a number of subcomponents. Consequently, for these Asset Categories, separate Health Score Modifiers are evaluated for each subcomponent. In such cases, the appropriate Health Score Modifier is applied to determine the Current Health Score for each subcomponent of the asset.

The Health Score Modifier consists of three elements:-

i) a Health Score Factor, which is a multiplication factor, derived from Condition Modifiers, that is applied to the Initial Health Score;
ii) a Health Score Cap, which is a maximum limit that is applied to the product of the Initial Health Score and the Health Score Factor; and
iii) a Health Score Collar, which is a minimum limit that is applied to the product of the Initial Health Score and the Health Score Factor.

Where a cap or a collar is applied an explanation for the application is provided in the associated table values in the appropriate appendices.

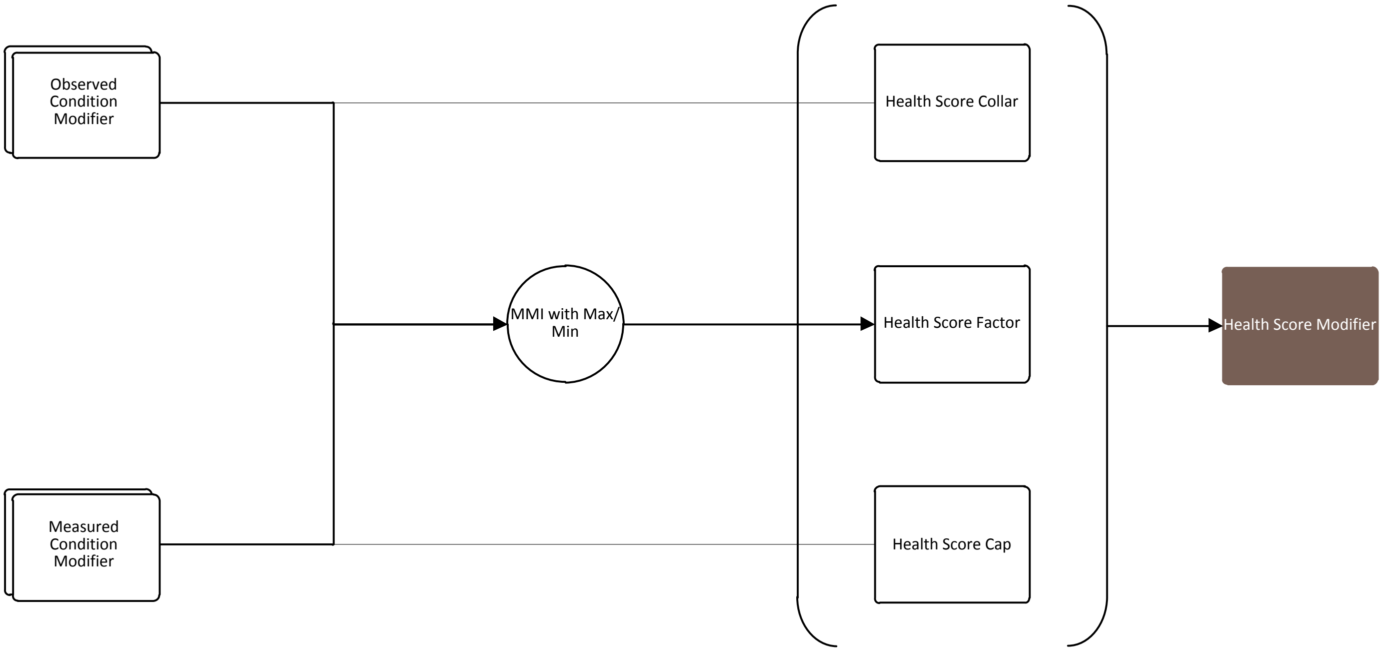

FIGURE 12: HEALTH SCORE MODIFIER

For assets, other than those in the EHV Transformer and 132kV Transformer Health Index Asset Categories, the Health Score Modifier is determined by combining:-

i) an Observed Condition Modifier, based on Observed Condition Inputs (such as condition assessment observations); and
ii) a Measured Condition Modifier, based on Measured Condition Inputs.

The derivation of the Observed Condition Modifier and Measured Condition Modifier are described in Sections 6.9 and 6.10. Like the Health Score Modifier, each of these Condition Modifiers is comprised of three elements, i.e.:-

i) a Condition Factor, which is a value associated with an observation or measurement, used to derive the Health Score Factor;
ii) a Condition Cap, which is a maximum limit that is used to derive the Health Score Cap; and
iii) a Condition Collar, which is a minimum limit that is used to derive the Health Score Collar.

The derivation of the Health Score Modifier for the EHV Transformer and 132kV Transformer Asset Categories is described separately in Section 6.8*.*

In determining the Health Score Modifier, only the Condition Modifiers (and associated Condition Inputs) specified within the Methodology are applied. In recognition of different inspection and assessment approaches between DNOs:-

i) There is no requirement for data to be collected to apply all the Condition Inputs specified within the Methodology. Where DNOs do not have data available to determine a specific Condition Input, the default values for that Condition Input (as specified in the calibration table for that Condition Input) are applied.
ii) The calibration tables for each Condition Input (Appendices B.5 and B.6) are defined in terms of the outcomes or conclusions drawn from the relevant condition assessments or tests and are common to all DNOs. Where required, DNOs shall map data from their own systems against the relevant criteria shown on the

calibration tables. This enables common Condition Inputs to be determined for all DNOs without specifying the exact format of data that is collected in each individual DNOs inspection and assessment regimes.

iii) It will be permissible for DNOs to combine multiple measurements or observations from their own data set (or adjust for elapsed time since the condition data was collected) in their mapping to an individual Condition Input.

DNOs shall be required to record all mappings of their data to the Methodology's Condition Inputs within their own Network Asset Indices Methodology.

6.7.2 Combining Factors Using a Maximum and Multiple Increment (MMI) Technique

The Condition Factors, which form part of the Condition Modifiers, are combined together to derive the Health Score Factor using a technique that is referred to as "maximum and multiple increment". The calculation of the Health Score Factor is described in Section 6.7.3.

Each specific Condition Factor is derived from multiple Condition Input Factors, which come from associated lookup tables that map the observed or measured condition to a Condition Input Factor.

The combination of Condition Inputs to create the Observed Condition Modifier and the Measured Condition Modifier is described in Sections 6.9 and 6.10. This also uses an MMI approach.

By using the MMI approach throughout, this ensures that the Health Score Factor is primarily driven by the strongest observed or measured Condition Input Factor, supplemented to a lesser and controlled degree by any additional Condition Input Factors (depending on their strength).

This approach enables a single methodology to be applied to all asset groups, with the variation between asset groups captured through calibration factors.

Whilst multiple Factors may be considered in the derivation of a single combined Factor using the MMI technique, there will be instances where not all of the multiple Factors affect the resulting Factor. This is because:-

i) where all of the multiple Factors are less than, or equal to 1, the resulting combined single Factor is determined from only the lowest and second lowest of the multiple Factors; and

ii) where any of the multiple Factors are greater than 1, the resulting combined single Factor will be determined from consideration of the highest of the multiple Factors and a given number of the next highest Factors. The total number of Factors considered in each case will be no greater than the Max. No. of Combined Factors, which is a calibration parameter that is specified for each instance that the MMI technique is applied. The Max. No. of Combined Factors describes the total number of Factors that may be considered in the derivation of the combined single Factor, which is a count of Factors that includes the maximum Factor and any additional Factors that may be used to supplement it.

The combination of multiple Factors into a single Factor using the MMI technique is described below:-

If any of the Factors is greater than 1:

- Var_1 = Maximum of Factors
- Var_2 = Excluding Var_1,
  - o For remaining Factors where (Factor - 1) > 0
  - o Sum (Factor - 1) for the highest n-1 of these; where *n* = *Max. No. of Combined Factors*
- Var_3 = Var_2 / Factor Divider 1
- Combined Factor = Var_1 + Var_3

o Else

- Var_1 = Minimum of Factors
- Var_2 = Second Lowest of Factors
- Var_3 = (Var_2 - 1) / Factor Divider 2
- Combined Factor = Var_1 + Var_3

Where:

- *Max. No. of Combined Factors specifies how many Factors are able to simultaneously affect the Combined Factor.*
- *Factor Divider 1 and Factor Divider 2 are constants that specify the degree to which additional "good" or "bad" Factors are able further drive the Combined Factor.*

A case statement description of this algorithm is demonstrated below.

Case 1: one or more Factors > 1

- Factors = 1.2, 1.0, 1.1, 1.02, 0.9, Max. No of Combined Factors = 4, Factor Divider 1 and Factor Divider 2 = 2
- Var 1 = maximum of Factors = Max(1.2, 1.0, 1.1, 1.02, 0.9) = 1.2
- Var 2 = sum remaining Factors where Factor - 1 > 0 = (1.1-1) + (1.02 - 1) = 0.12
- Var 3 = Var 2 / Factor Divider 1 = 0.12 / 2 = 0.06
- Combined Factor = Var 1 + Var 3 = 1.2 + 0.06 = 1.26

Case 2: all Factors ≤ 1

- Factors = 1, 1, 0.8, 1, 0.9, Max. No of Combined Factors = 4, Factor Divider 1 and Factor Divider 2 = 2
- Var 1 = minimum of Factors = Min(1, 1, 0.8, 0.9) = 0.8
- Var 2 = Second minimum of Factors = 2^{nd}Min(1, 1, 0.8, 0.9) = 0.9
- Var 3 = (Var 2 - 1) / Factor Divider 2 = (0.9 - 1) / 2 = -0.05
- Combined Factor = Var 3 + Var 1 = 0.8 + -0.05 = 0.75

6.7.3 Health Score Factor Calculation

The Health Score Factor is a multiplier that is applied to the Initial Health Score.

The Observed and Measured Condition Factors are combined to derive the Health Score Factor using the MMI technique described in Section 6.7.2.

For assets, other than those in the EHV Transformer and 132kV Transformer Health Index Asset Categories, Factor Divider 1 and Factor Divider 2 have a value of 1.5 and the Max. No. of Combined Factors is 2. This means that the description of the combination method can be simplified to:-

i) The Health Score Factor for an individual asset is determined by evaluating:-
   - the maximum of the Observed Condition Factor and the Measured Condition Factor for the asset; and
   - the minimum of the Observed Condition Factor and the Measured Condition Factor for the asset.

ii) The calculation used to determine the Health Score Factor is dependent on the magnitudes of the maximum and minimum Condition Factors. The Health Score Factor is calculated as shown in Table 9.

TABLE 9: HEALTH SCORE FACTOR

a = Maximum of (Observed Condition Factor, Measured Condition Factor)	**b =** Minimum of (Observed Condition Factor, Measured Condition Factor)	**Health Score Factor**
>1	>1	= a + ((b-1)/1.5)
>1	≤1	= a
≤1	≤1	= b + ((a-1)/1.5)

The derivation of the Health Score Factor for the EHV Transformer and 132kV Transformer Asset Categories is described separately in Section 6.8.

6.7.4 Health Score Cap

For assets, other than those in the EHV Transformer and 132kV Transformer Health Index Asset Categories, the Health Score Cap is the minimum of:-

i) The Observed Condition Cap associated with the Observed Condition Modifier; or
ii) The Measured Condition Cap associated with the Measured Condition Modifier.

The derivation of the Condition Caps associated with the Observed and Measured Condition Modifiers is described in Sections 6.9.3 and 6.10.3 respectively.

The derivation of the Health Score Cap for the EHV Transformer and 132kV Transformer Asset Categories is described in Section 6.8.

6.7.5 Health Score Collar

For assets, other than those in the EHV Transformer and 132kV Transformer Health Index Asset Categories, the Health Score Collar is the maximum of:-

i) The Observed Condition Collar associated with the Observed Condition Modifier; or
ii) The Measured Condition Collar associated with the Measured Condition Modifier.

The derivation of the Condition Collars associated with the Observed and Measured Condition Modifiers is described in Sections 6.9.4 and 6.10.4 respectively.

The derivation of the Health Score Collar for the EHV Transformer and 132kV Transformer Asset Categories is described in Section 6.8.

In all cases, the Health Score Collar shall be limited to a value of no greater than 10.

6.8 Health Score Modifier for EHV and 132kV Transformers

6.8.1 Main Transformer

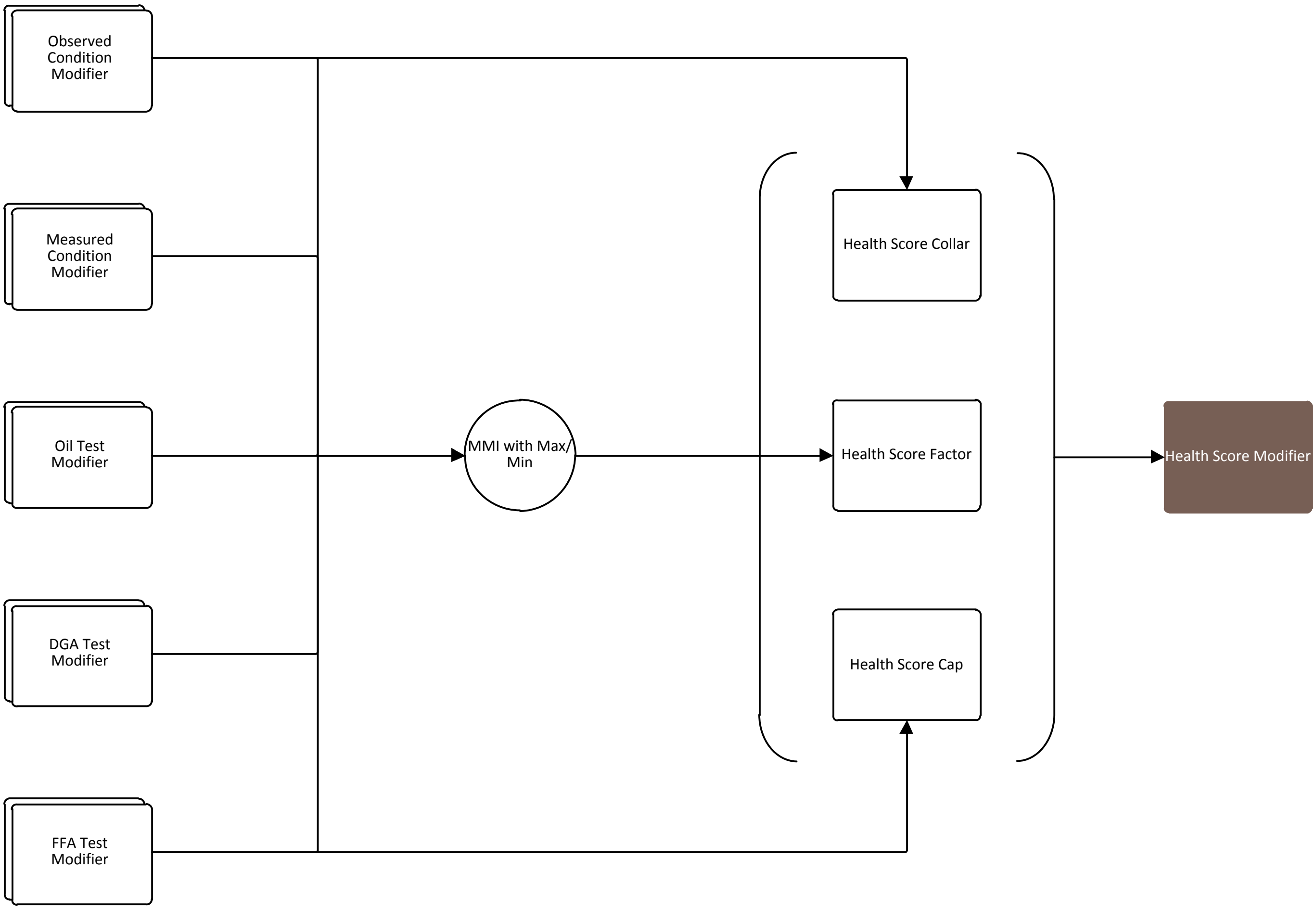

FIGURE 13: HEALTH SCORE MODIFIER - MAIN TRANSFORMER

The Health Score Modifier for EHV and 132kV Transformers is derived in exactly the same way as for a generic Health Score Modifier, apart from the following differences:

i) There are three additional Condition Modifiers to the model: the Oil Test Modifier, the DGA Test Modifier and the FFA Test Modifier.

ii) The parameters used to combine the Factors associated with these Condition Modifiers in order to derive the Health Score Factor are as shown in Table 10.

TABLE 10: HEALTH SCORE FACTOR FOR TRANSFORMERS

Parameters for Combination Using MMI Technique		
Factor Divider 1	Factor Divider 2	Max. No. of Condition Factors
1.5	1.5	4

These additional inputs enable the Health Score of the Main Transformer component to be determined with greater accuracy.

6.8.2 Tapchanger

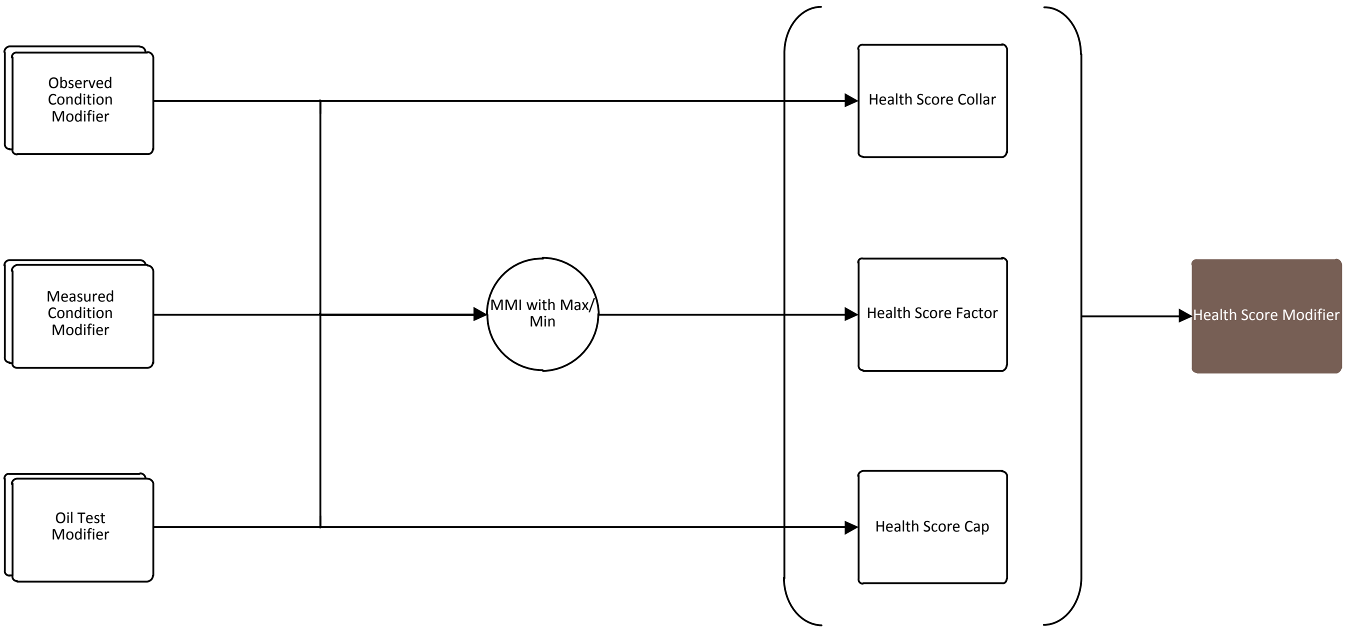

FIGURE 14: HEALTH SCORE MODIFIER - TAPCHANGER

The Health Score Modifier for a Transformer Tapchanger (where the Health Score needs to be separately determined) is derived in exactly the same way as for a generic Health Score Modifier, apart from the following differences:

i) There is an additional Condition Modifier to the model: the Oil Test Modifier.

ii) The parameters used to combine the Factors associated with these Condition Modifiers in order to derive the Health Score Factor are as shown in Table 11.

TABLE 11: HEALTH SCORE FACTOR FOR TAPCHANGERS

Parameters for Combination Using MMI Technique		
Factor Divider 1	**Factor Divider 2**	**Max. No. of Condition Factors**
1.5	1.5	2

This additional input enables the Health Score of the Tapchanger to be determined with greater accuracy.

6.9 Observed Condition Modifier

6.9.1 Overview

The Observed Condition Modifier is used in the determination of the Health Score Modifier.

An asset-specific Observed Condition Modifier is determined for each individual asset. For all Health Index Asset Categories, with the exception of EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers, a single Observed Condition Modifier is calculated for each asset.

The calculation of Health Score for assets in the EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers Health Index Asset Categories requires separate evaluation of the Health Score for subcomponents of these assets. Consequently, for these Asset Categories, separate Observed Condition Modifiers are evaluated for each subcomponent associated with each asset.

This Condition Modifier is based on observed condition.

The Observed Condition Modifier consists of three components:-

i) an Observed Condition Factor, which used in the derivation of the Health Score Factor;
ii) an Observed Condition Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and
iii) an Observed Condition Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

Multiple Observed Condition Inputs are used to derive the Observed Condition Modifier. Each Observed Condition Input consists of three elements:-

i) a Condition Input Factor;
ii) a Condition Input Cap; and
iii) a Condition Input Collar.

The Condition Input Factors are used to derive the Observed Condition Factor using the MMI technique described in Section 6.7.2. Each Condition Input Cap is used in the derivation of the Observed Condition Cap and each Condition Input Collar is used in the derivation of the Observed Condition Collar.

The calibration tables relating to each of the Observed Condition Inputs are shown in Appendix B.5. The values assigned to each Condition Input, for a particular asset, are determined by looking up the relevant Condition Input values that correspond to the DNO's data for that asset.

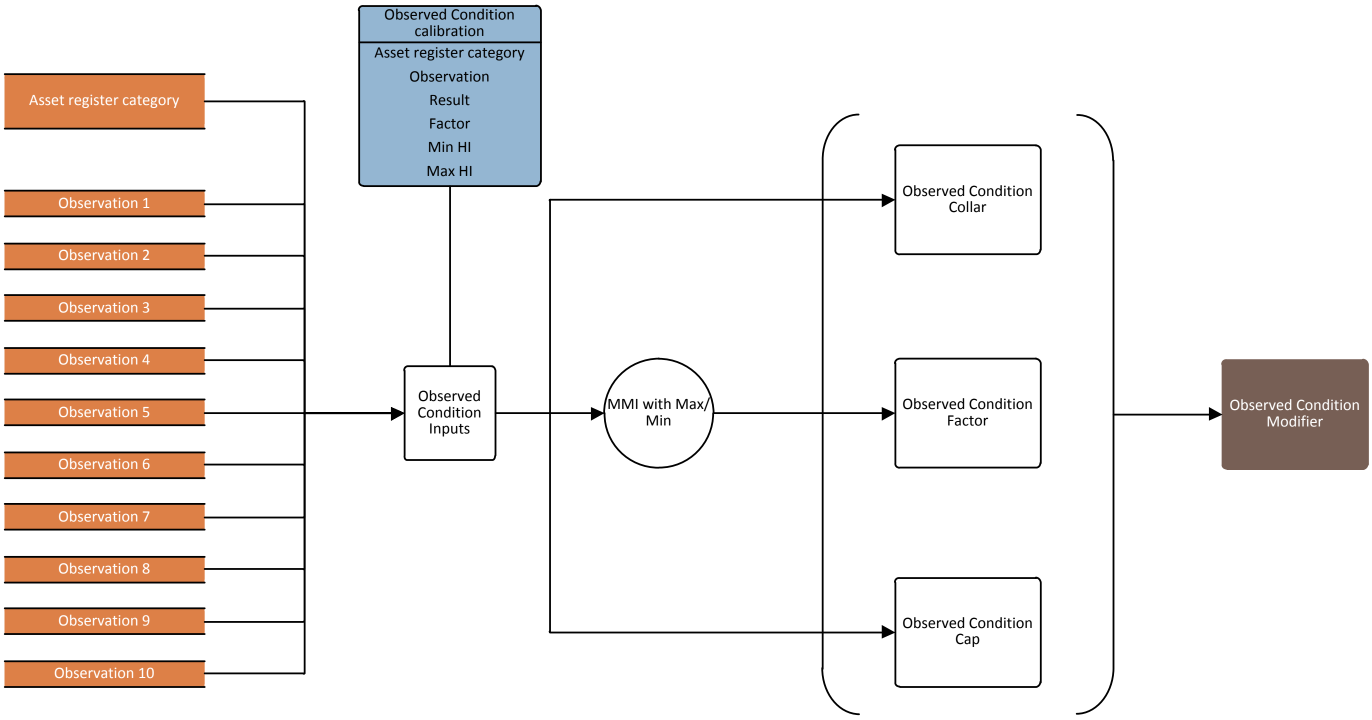

FIGURE 15: OBSERVED CONDITION MODIFIER

Table 12 shows the Observed Condition Inputs that are included in the determination of the Observed Condition Modifier for each Asset Category.

TABLE 12: OBSERVED CONDITION INPUTS

Asset Category	Subcomponent	Observed Condition Input
LV UGB	N/A	1. Steel Cover and Pit condition 2. Water/Moisture 3. Bell Condition 4. Insulation Condition 5. Signs of heating 6. Phase Barriers
LV Circuit Breaker	N/A	1. Switchgear external condition
LV Board (WM)	N/A	1. Switchgear external condition 2. Compound Leaks 3. Switchgear internal condition
LV Pillars	N/A	1. Switchgear external condition 2. Compound Leaks 3. Switchgear internal condition 4. Insulation 5. Signs of Heating 6. Phase Barriers
HV Switchgear (GM) - Primary	N/A	1. Switchgear external condition 2. Oil leaks/ Gas pressure 3. Thermographic Assessment 4. Switchgear internal condition and operation 5. Indoor Environment

Asset Category	Subcomponent	Observed Condition Input
HV Switchgear (GM) - Distribution	N/A	1. Switchgear external condition 2. Oil leaks/ Gas pressure 3. Thermographic Assessment 4. Switchgear internal condition and operation 5. Indoor Environment
EHV Switchgear (GM)	N/A	1. Switchgear external condition 2. Oil leaks/ Gas pressure 3. Thermographic Assessment 4. Switchgear internal condition and operation 5. Indoor Environment 6. Support Structures
132kV Switchgear (GM)	N/A	1. Switchgear external condition 2. Oil leaks/ Gas pressure 3. Thermographic Assessment 4. Switchgear internal condition and operation 5. Indoor Environment 6. Support Structures 7. Air systems
HV Transformer (GM)	N/A	1. Transformer external condition
EHV Transformer (GM)	Main Transformer	1. Main tank condition 2. Coolers/Radiator condition 3. Bushings condition 4. Kiosk condition 5. Cable boxes condition
	Tapchanger	1. Tapchanger external condition 2. Internal Condition 3. Drive Mechanism Condition 4. Condition of Selector & Diverter Contacts 5. Condition of Selector & Diverter Braids
132kV Transformer (GM)	Main Transformer	1. Main tank condition 2. Coolers/Radiator condition 3. Bushings condition 4. Kiosk condition 5. Cable boxes condition
	Tapchanger	1. Tapchanger external condition 2. Internal Condition 3. Drive Mechanism Condition 4. Condition of Selector & Diverter Contacts 5. Condition of Selector & Diverter Braids
EHV Cable (Non Pressurised)	N/A	None
EHV Cable (Oil)	N/A	None
EHV Cable (Gas)	N/A	None
132kV Cable (Non Pressurised)	N/A	None
132kV Cable (Oil)	N/A	None
132kV Cable (Gas)	N/A	None
Submarine Cable	N/A	1. External Condition of Armour
LV Poles	N/A	1. Visual Pole Condition 2. Pole Top Rot 3. Pole Leaning 4. Bird / Animal Damage

<table>
<tr><th>Asset Category</th><th>Subcomponent</th><th>Observed Condition Input</th></tr>
<tr><td>HV Poles</td><td>N/A</td><td>1. Visual Pole Condition
2. Pole Top Rot
3. Pole Leaning
4. Bird / Animal Damage</td></tr>
<tr><td>EHV Poles</td><td>N/A</td><td>1. Visual Pole Condition
2. Pole Top Rot
3. Pole Leaning
4. Bird / Animal Damage</td></tr>
<tr><td rowspan="3">EHV Towers</td><td>Tower Steelwork</td><td>1. Tower Legs
2. Bracings
3. Crossarms
4. Peak</td></tr>
<tr><td>Tower Paintwork</td><td>1. Paintwork Condition</td></tr>
<tr><td>Foundations</td><td>1. Foundation Condition</td></tr>
<tr><td rowspan="3">132kV Towers</td><td>Tower Steelwork</td><td>1. Tower Legs
2. Bracings
3. Crossarms
4. Peak</td></tr>
<tr><td>Tower Paintwork</td><td>1. Paintwork Condition</td></tr>
<tr><td>Foundations</td><td>1. Foundation Condition</td></tr>
<tr><td>EHV Fittings</td><td>N/A</td><td>1. Tower fittings
2. Conductor fittings
3. Insulators - Electrical
4. Insulators - Mechanical</td></tr>
<tr><td>132kV Fittings</td><td>N/A</td><td>1. Tower fittings
2. Conductor fittings
3. Insulators - Electrical
4. Insulators - Mechanical</td></tr>
<tr><td>EHV Tower Line Conductor</td><td>N/A</td><td>1. Visual Condition
2. Midspan joints</td></tr>
<tr><td>132kV Tower Line Conductor</td><td>N/A</td><td>1. Visual Condition
2. Midspan joints</td></tr>
</table>

6.9.2 Observed Condition Factor

The Observed Condition Factor is used in the derivation of the Health Score Factor.

For each asset, multiple Observed Condition Input Factors are combined to create the Observed Condition Factor. These Observed Condition Input Factors are combined using the MMI technique that is described in Section 6.7.2.

Table 13 shows the parameters that are used when combining the Observed Condition Input Factors using the MMI technique.

TABLE 13: OBSERVED CONDITION MODIFIER - MMI CALCULATION PARAMETERS

Asset Category	Subcomponent	Parameters for Combination Using MMI Technique		
		Factor Divider 1	Factor Divider 2	Max. No. of Combined Factors
LV UGB	N/A	1.5	1.5	3
LV Circuit Breaker	N/A	1.5	1.5	1
LV Board (WM)	N/A	1.5	1.5	2
LV Pillars	N/A	1.5	1.5	3
HV Switchgear (GM) - Primary	N/A	1.5	1.5	3
HV Switchgear (GM) - Distribution	N/A	1.5	1.5	3
EHV Switchgear (GM)	N/A	1.5	1.5	3
132kV Switchgear (GM)	N/A	1.5	1.5	3
HV Transformer (GM)	N/A	1.5	1.5	1
EHV Transformer (GM)	Main Transformer	1.5	1.5	3
	Tapchanger	1.5	1.5	3
132kV Transformer (GM)	Main Transformer	1.5	1.5	3
	Tapchanger	1.5	1.5	3
EHV Cable (Non Pressurised)	N/A	N/A	N/A	N/A
EHV Cable (Oil)	N/A	N/A	N/A	N/A
EHV Cable (Gas)	N/A	N/A	N/A	N/A
132kV Cable (Non Pressurised)	N/A	N/A	N/A	N/A
132kV Cable (Oil)	N/A	N/A	N/A	N/A
132kV Cable (Gas)	N/A	N/A	N/A	N/A
Submarine Cable	N/A	1.5	1.5	1
LV Poles	N/A	1.5	1.5	2
HV Poles	N/A	1.5	1.5	2
EHV Poles	N/A	1.5	1.5	2
EHV Towers	Tower Steelwork	1.5	1.5	3
	Tower Paintwork	1.5	1.5	1
	Foundations	1.5	1.5	1
132kV Towers	Tower Steelwork	1.5	1.5	3
	Tower Paintwork	1.5	1.5	1
	Foundations	1.5	1.5	1
EHV Fittings	N/A	1.5	1.5	3
132kV Fittings	N/A	1.5	1.5	3
EHV Tower Line Conductor	N/A	1.5	1.5	1
132kV Tower Line Conductor	N/A	1.5	1.5	1

6.9.3 Observed Condition Cap

The Observed Condition Cap for an asset is the minimum value of Condition Input Cap associated with each of the Observed Condition Inputs relating to that asset (as shown in the calibration tables for Observed Condition Inputs in Appendix B).

6.9.4 Observed Condition Collar

The Observed Condition Collar for an asset is the maximum value of Condition Input Collar associated with each of the Observed Condition Inputs relating to that asset (as shown in the calibration tables for Observed Condition Inputs in Appendix B).

6.9.5 Observed Condition Modifier for Cable Assets

There are no Observed Condition Inputs for cable assets other than Submarine Cables. For all cable assets with the exception of Submarine Cables:-

i) the Observed Condition Factor is set to 1;
ii) the Observed Condition Cap is 10; and
iii) the Observed Condition Collar is 0.5.

6.10 Measured Condition Modifier

6.10.1 Overview

The Measured Condition Modifier is used in the determination of the Health Score Modifier.

An asset-specific Measured Condition Modifier is determined for each individual asset.

For all Health Index Asset Categories, with the exception of EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers, a single Measured Condition Modifier is calculated for each asset.

The calculation of Health Score for assets in the EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers Health Index Asset Categories requires separate evaluation of the Health Score for subcomponents of these assets. Consequently, for these Asset Categories, separate Measured Condition Modifiers are evaluated for each subcomponent associated with each asset.

This Condition Modifier is based on measured condition.

The Measured Condition Modifier consists of three components:-

i) a Measured Condition Factor, which is used in the derivation of the Health Score Factor;
ii) a Measured Condition Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and
iii) a Measured Condition Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

Multiple Measured Condition Inputs are used to derive the Measured Condition Modifier. Each Measured Condition Input consists of three elements:-

i) a Condition Input Factor;
ii) a Condition Input Cap; and
iii) a Condition Input Collar.

The Condition Input Factors are used to derive the Measured Condition Factor using the MMI technique described in Section 6.7.2. Each Condition Input Cap is used in the derivation of the

Measured Condition Cap and each Condition Input Collar is used in the derivation of the Measured Condition Collar.

The calibration tables relating to each of the Measured Condition Inputs are shown in Appendix B.6. The values assigned to each Condition Input for a particular asset are determined by looking up the relevant Condition Input values that correspond to the DNO's data for that asset.

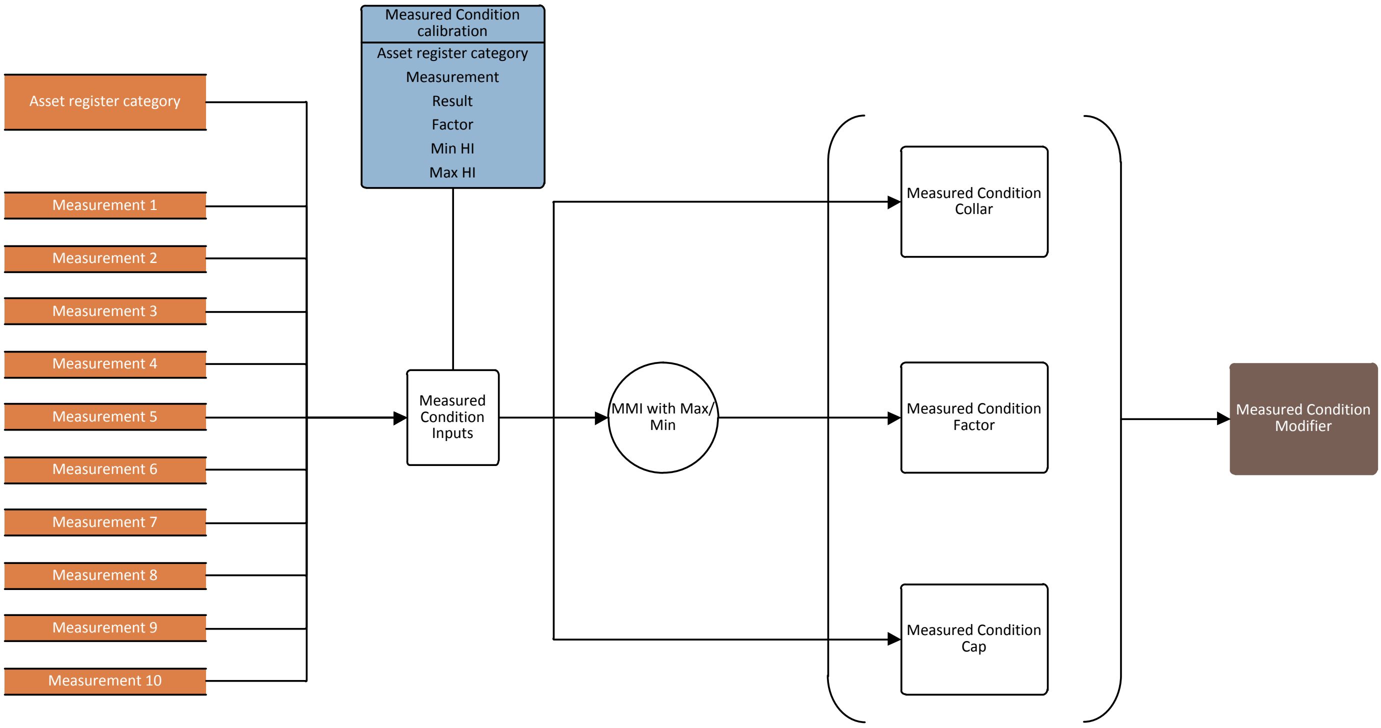

FIGURE 16: MEASURED CONDITION MODIFIER

Table 14 shows the Measured Condition Inputs that are included in the determination of the Measured Condition Modifier for each Asset Category.

TABLE 14: MEASURED CONDITION INPUTS

Asset Category	Subcomponent	Measured Condition Input
LV UGB	N/A	1. Operational Adequacy
LV Circuit Breaker	N/A	1. Operational Adequacy
LV Board (WM)	N/A	1. Operational Adequacy 2. Security
LV Pillars	N/A	1. Operational Adequacy
HV Switchgear (GM) - Primary	N/A	1. Partial Discharge 2. Ductor Test 3. IR Test 4. Oil Tests 5. Temperature Readings 6. Trip Test
HV Switchgear (GM) - Distribution	N/A	1. Partial Discharge 2. Ductor Test 3. Oil Tests 4. Temperature Readings 5. Trip Test

Asset Category	Subcomponent	Measured Condition Input
EHV Switchgear (GM)	N/A	1. Partial Discharge 2. Ductor Test 3. IR Test 4. Oil Tests/ Gas Tests 5. Temperature Readings 6. Trip Test
132kV Switchgear (GM)	N/A	1. Partial Discharge 2. Ductor Test 3. IR Test 4. Oil Tests/ Gas Tests 5. Temperature Readings 6. Trip Test
HV Transformer (GM)	N/A	1. Partial Discharge 2. Oil Acidity 3. Temperature Readings
EHV Transformer (GM)	Main Transformer	1. Partial Discharge 2. Temperature Readings
	Tapchanger	1. Tapchanger Partial Discharge
132kV Transformer	Main Transformer	1. Partial Discharge 2. Temperature Readings
	Tapchanger	1. Tapchanger Partial Discharge
EHV Cable (Non Pressurised)	N/A	1. Sheath Test 2. Partial Discharge 3. Fault history
EHV Cable (Oil)	N/A	1. Leakage
EHV Cable (Gas)	N/A	1. Leakage
132kV Cable (Non Pressurised)	N/A	1. Sheath Test 2. Partial Discharge 3. Fault history
132kV Cable (Oil)	N/A	1. Leakage
132kV Cable (Gas)	N/A	1. Leakage
Submarine Cable	N/A	1. Sheath Test 2. Partial Discharge 3. Fault history
LV Poles	N/A	1. Pole decay / deterioration
HV Poles	N/A	1. Pole decay / deterioration
EHV Poles	N/A	1. Pole decay / deterioration
EHV Towers	Tower Steelwork	None
	Tower Paintwork	None
	Foundations	None
132kV Towers	Tower Steelwork	None
	Tower Paintwork	None
	Foundations	None
EHV Fittings	N/A	1. Thermal Imaging 2. Ductor Tests
132kV Fittings	N/A	1. Thermal Imaging 2. Ductor Tests

Asset Category	Subcomponent	Measured Condition Input
EHV Tower Line Conductor	N/A	1. Conductor Sampling 2. Corrosion Monitoring Survey
132kV Tower Line Conductor	N/A	1. Conductor Sampling 2. Corrosion Monitoring Survey

6.10.2 Measured Condition Factor

The Measured Condition Factor is used in the derivation of the Health Score Factor.

For each asset, multiple Measured Condition Input Factors are combined to create the Measured Condition Factor. These Measured Condition Input Factors are combined using the MMI technique that is described in Section 6.7.2.

Table 15 shows the parameters that are used when combining the Measured Condition Factors using the MMI technique.

TABLE 15: MEASURED CONDITION MODIFIER - MMI CALCULATION PARAMETERS

Asset Category	Subcomponent	Parameters for Combination Using MMI Technique		
		Factor Divider 1	Factor Divider 2	Max. No. of Combined Factors
LV UGB	N/A	1.5	1.5	1
LV Circuit Breaker	N/A	1.5	1.5	1
LV Board (WM)	N/A	1.5	1.5	2
LV Pillars	N/A	1.5	1.5	1
HV Switchgear (GM) - Primary	N/A	1.5	1.5	3
HV Switchgear (GM) - Distribution	N/A	1.5	1.5	3
EHV Switchgear (GM)	N/A	1.5	1.5	3
132kV Switchgear (GM)	N/A	1.5	1.5	3
HV Transformer (GM)	N/A	1.5	1.5	2
EHV Transformer (GM)	Main Transformer	1.5	1.5	2
	Tapchanger	1.5	1.5	1
132kV Transformer (GM)	Main Transformer	1.5	1.5	2
	Tapchanger	1.5	1.5	1
EHV Cable (Non Pressurised)	N/A	1.5	1.5	2
EHV Cable (Oil)	N/A	1.5	1.5	1
EHV Cable (Gas)	N/A	1.5	1.5	1
132kV Cable (Non Pressurised)	N/A	1.5	1.5	2
132kV Cable (Oil)	N/A	1.5	1.5	1
132kV Cable (Gas)	N/A	1.5	1.5	1
Submarine Cable	N/A	1.5	1.5	2
LV Poles	N/A	1.5	1.5	1
HV Poles	N/A	1.5	1.5	1
EHV Poles	N/A	1.5	1.5	1
EHV Towers	Tower Steelwork	N/A	N/A	N/A
	Tower Paintwork	N/A	N/A	N/A
	Foundations	N/A	N/A	N/A
132kV Towers	Tower Steelwork	N/A	N/A	N/A
	Tower Paintwork	N/A	N/A	N/A
	Foundations	N/A	N/A	N/A
EHV Fittings	N/A	1.5	1.5	1
132kV Fittings	N/A	1.5	1.5	1
EHV Tower Line Conductor	N/A	1.5	1.5	1

Asset Category	Subcomponent	Parameters for Combination Using MMI Technique		
		Factor Divider 1	Factor Divider 2	Max. No. of Combined Factors
132kV Tower Line Conductor	N/A	1.5	1.5	1

6.10.3 Measured Condition Cap

The Measured Condition Cap for an asset is the minimum value of Condition Input Cap associated with each of the Measured Condition Inputs relating to that asset (as shown in the calibration tables for Measured Condition Inputs in Appendix B).

6.10.4 Measured Condition Collar

The Measured Condition Collar for an asset is the maximum value of Condition Input Collar associated with each of the Measured Condition Inputs relating to that asset (as shown in the calibration tables for Measured Condition Inputs in Appendix B).

6.10.5 Measured Condition Modifier for Steel Towers (Structure Only)

There are no Measured Condition Inputs for Steel Towers (Steelwork, Paint or Foundation components). For these assets:-

i) the Measured Condition Factor is set to 1;
ii) the Measured Condition Cap is 10; and
iii) the Measured Condition Collar is 0.5.

6.11 Oil Test Modifier

The Oil Test Modifier is derived from the oil condition information (moisture content, acidity and breakdown strength) [Ref. 3 & 4]. It provides additional information to determine the Health Score when oil condition test data is available. This test data can be used to identify defects or degradation within the asset, and is therefore used to increase the Health Score when necessary.

The Oil Test Modifier consists of three components:-

i) An Oil Test Factor, which used in the derivation of the Health Score Factor;
ii) an Oil Test Cap, which is a maximum limit of Health Score that used in the derivation of the Health Score Cap; and
iii) an Oil Test Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

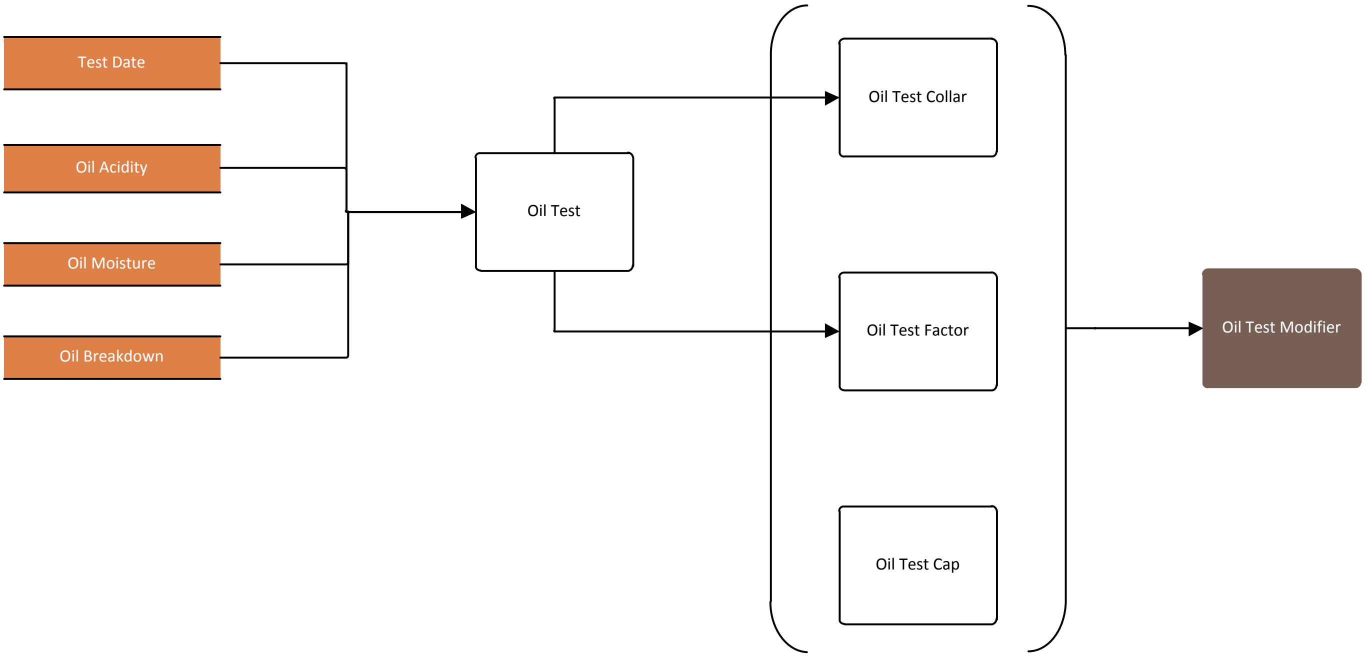

FIGURE 17: OIL TEST MODIFIER

The process for converting the results into a score and subsequently into an Oil Test Factor, an Oil Test Cap and an Oil Test Collar is as follows:

i) The moisture, acidity and breakdown strength results are standardised by converting them into scores using the Condition State calibration tables; respectively Tables 196, 197 and 198 in Appendix B.
ii) The scores for the three condition points (moisture, breakdown strength and acidity) are then multiplied by the values relative to the importance of the measured condition point and summed to create an Oil Condition Score as shown in Eq. 20.

$$\text{Oil Condition Score} = 80 \times \text{Moisture Score} + 125 \times \text{Acidity Score} + 80 \times \text{Breakdown Strength Score} \quad \text{(Eq. 20)}$$

iii) The Oil Condition Factor and Oil Test Collar value are then derived using the lookup values shown in Tables 199 and 200 in Appendix B.
iv) The Oil Test Cap is always set to 10: because oil can be renewed, oil tests are unable to determine the absence of degradation in an asset - only its presence. Therefore the Oil Test Cap cannot be set to less than 10, regardless of the Oil Test result.

6.12 DGA Test Modifier

The DGA Test Modifier is derived from the dissolved gas content in the oil [Ref. 5]. It provides additional information to determine the Health Score when DGA test data is available. This test data can be used to detect abnormal electrical or thermal activity within the asset, and is therefore used to increase the Health Score when necessary.

The DGA Test Modifier consists of three components:-

i) a DGA Test Factor, which is used in the derivation of the Health Score Factor;
ii) a DGA Test Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and
iii) a DGA Test Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

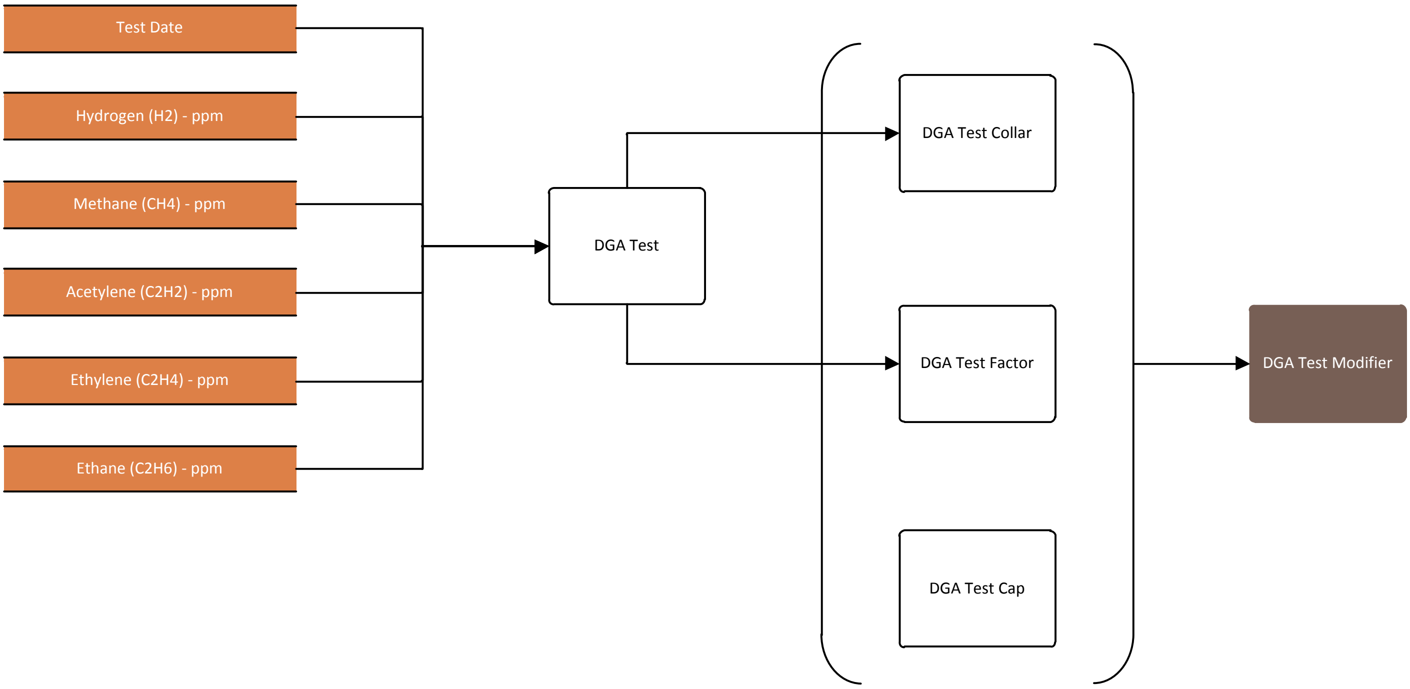

FIGURE 18: DGA TEST MODIFIER

The diagnostic process described here was developed by EA Technology in conjunction with a number of GB Distribution Network Operators within Module 4 of the Strategic Technology Programme [Ref. 4]. Of nine gases measured during DGA (namely oxygen, nitrogen, carbon monoxide, carbon dioxide, hydrogen, methane, ethylene, ethane and acetylene) only the latter five were recognised as providing an indication of transformer condition.

Therefore, only the levels of the following gases are used to derive the DGA Test Modifier:-

i) Hydrogen;
ii) Methane;
iii) Ethylene;
iv) Ethane; and
v) Acetylene.

The gas levels used to produce this modifier are calibrated to give a DGA Test Collar of 7 or greater if there is indication of a potential end of life fault. The result of this analysis is used to determine the DGA Test Collar and the DGA Test Factor. The DGA Test Cap is always set to 10.

The results for each of the five gases are standardised by converting them into scores using condition state calibration tables; these are shown in Tables 201 - 205 in Appendix B.

The condition state scores for the five gases (hydrogen, methane, ethane, ethylene and acetylene) are then multiplied by values relative to the importance of the quantity of each gas measured and summed to create a DGA Score as shown in Eq. 21.

$$\text{DGA Score} = 50 \times \text{Hydrogen Score} + 30 \times \text{Methane Score} + 30 \times \text{Ethylene Score} + 30 \times \text{Ethane Score} + 120 \times \text{Acetylene Score} \quad \text{(Eq. 21)}$$

In order to create a DGA Test Collar in the range of 1 to 10, the DGA Score is divided by a DGA divider value; this is set at 220 as shown in Eq. 22.

$$\text{DGA Test Collar} = \text{DGA Score} \div 220 \quad \text{(Eq. 22)}$$

This value is chosen to give a Health Score of 7 at the point where DGA levels are indicative of severe degradation.

The DGA Test Factor is then created by considering the trend with historical results (over a defined period) for the same asset. The percentage change is derived as shown in Eq. 23.

$$\%\ \text{Change} = \frac{\text{DGA Score}_{\text{latest}} - \text{DGA Score}_{\text{previous}}}{\text{DGA Score}_{\text{previous}}} \times 100\% \quad \text{(Eq. 23)}$$

This is used to categorise the trend into one of five categories or bands (negative, neutral, small, significant or large), as depicted in calibration Table 206 in Appendix B.

The category or band is then used to assign the DGA Test Factor, using the calibration Table 207 in Appendix B.

The DGA Test Cap is always set to 10: because oil can be renewed, DGA tests are unable to determine the absence of degradation in an asset - only its presence. Therefore the DGA Test Cap cannot be set to less than 10, regardless of the DGA test result.

6.13 FFA Test Modifier

The FFA Test Modifier is derived from the level of furfuraldehyde (FFA) in oil. It provides additional information to determine the Health Score when FFA test data is available. This test data can be used to detect degradation of cellulose paper, and hence residual mechanical strength of insulation within the asset. It is used to increase the Health Score when necessary.

The FFA Test Modifier consists of three components:-

i) an FFA Test Factor, which is used in the derivation of the Health Score Factor;
ii) an FFA Test Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and
iii) an FFA Test Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

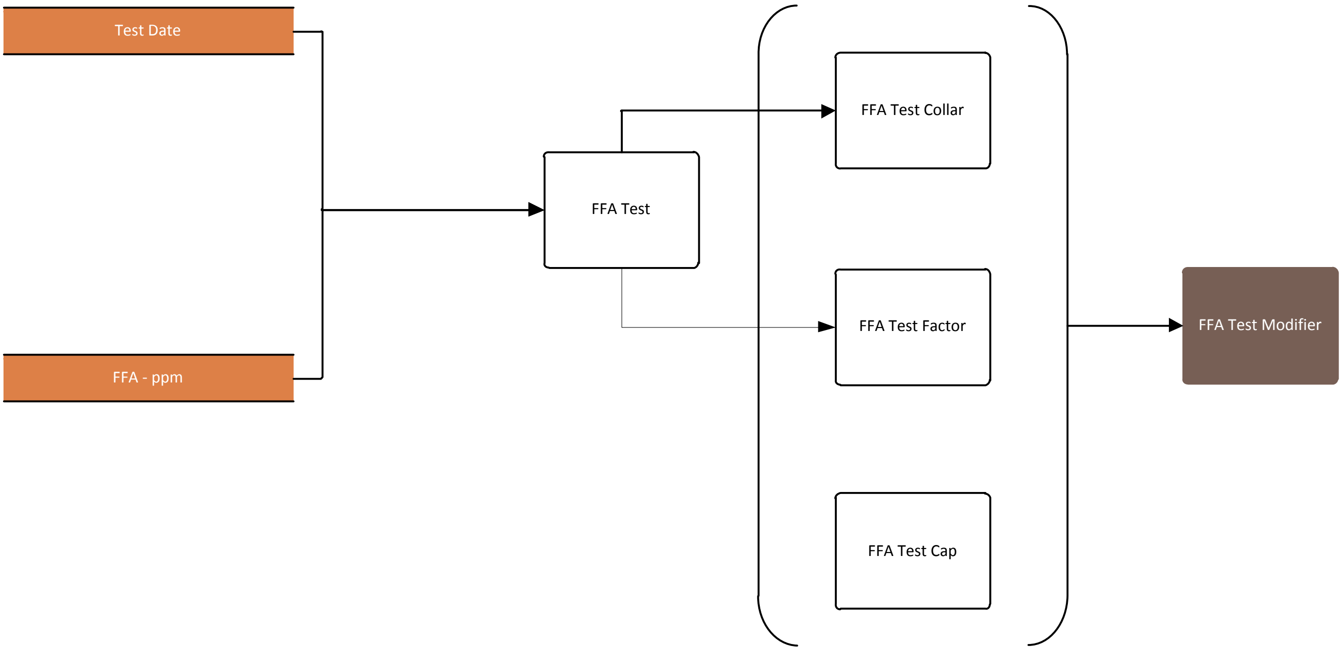

FIGURE 19: FFA TEST MODIFIER

The FFA Test Collar is derived from the furfuraldehyde (FFA) value.

Furfuraldehyde is one of a family of compounds (furans) produced when cellulose (paper) degrades. As the paper ages, the cellulose chains progressively break, reducing the mechanical strength. The average length of the cellulose chains is defined by the degree of polymerisation (DP) which is a measure of the number of Carbon-Carbon bonds or the length of chains making up the paper fibres. In a new transformer, the DP value is approximately 1000. When this is reduced to approximately 250, the paper has very little remaining strength and is at risk of failure during operation.

There is an approximate relationship between the value of furfuraldehyde in the oil and the DP of the paper, which has been established experimentally. A value of 5ppm of FFA is indicative of paper with a DP of approximately 250. For this reason, the FFA Test Collar is calibrated to give a value of 7 for a FFA value of 5; this empirical relationship has been mathematically described as shown in Eq. 24.

$$\text{FFA Test Collar} = 2.33 \times S^{0.68} \qquad \text{(Eq. 24)}$$

Where:

- *S is the FFA value in ppm.*

The FFA Test Factor is determined from the FFA value using the calibration Table 208 in Appendix B. The default value for the FFA Test Factor is 1.

The FFA Test Cap is always set to 10.

6.14 Reliability Modifier

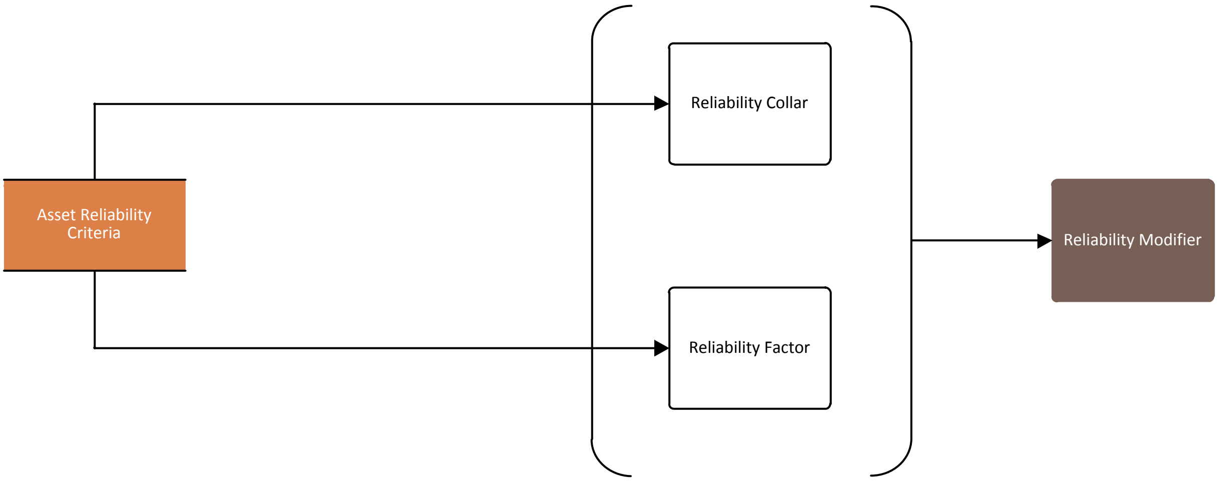

FIGURE 20: RELIABILITY MODIFIER

An additional Reliability Modifier may be applied (at individual DNO discretion) to the Current Health Score of those assets that the individual DNO believes have a materially different PoF than would be expected for a typical asset within the same Asset Category with the same Health Score, as a result of generic issues that affect health/reliability associated with:-

i) the make and type of the asset; and
ii) the construction of the asset (e.g. material used or treatment applied).

Typically these issues would have been identified from manufacturer notifications, failure investigations, forensic analysis or as a result of inspections from assets of the same make or type. This recognises that there are wider sources of knowledge about the condition and performance of individual assets.

Where a DNO applies a Reliability Modifier to a particular type of asset, this shall be documented within their own Network Asset Indices Methodology.

The Reliability Modifier may comprise of two separate components:-

i) a multiplication factor applied in the calculation of the Current Health Score (the Reliability Factor); and
ii) a Health Score Collar applied as a minimum limit to the Current Health Score (the Reliability Collar).

The Reliability Factor shall be applied as a multiplier to the Current Health Score that is derived from the initial age-based Health Score and the Health Score Modifier.

The Reliability Collar shall be applied as a minimum limit to the Health Score that is derived from the initial age-based Health Score, the Health Score Modifier and the Reliability Factor (where applied).

The Reliability Factor shall have a value between 0.6 and 1.5 with a default value of 1. The default value for the Reliability Collar shall be 0.5. Each DNO has discretion over whether the Reliability Modifier applied to individual asset types comprises:-

i) only a Reliability Factor;
ii) only a Reliability Collar; or
iii) both.

When applying Reliability Modifiers, individual DNOs may use any appropriate data they have relating to the asset or assets. This will include their own defect databases as well as information gathered as part of the national notification process for:-

i) National Equipment Defect Reports (NEDeRs);
ii) Dangerous Incident Notifications (DINs); or
iii) Suspension of Operational Practice notices (SOPs).

7. CONSEQUENCES OF FAILURE

7.1 Overview

The second key dimension of the Methodology is a consideration of the consequences of asset failure. This is used in combination with an assessment of the probability of asset failure to derive a single value for network risk.

The Methodology breaks the effects of failure down into four Consequence Categories:-

i) Financial;
ii) Safety;
iii) Environmental; and
iv) Network Performance.

Each of these is quantified in terms which allow for the monetisation within each Consequence Category. The four values are then simply added to produce an overall CoF value. All quoted values are in £ (at 2012/13 prices).

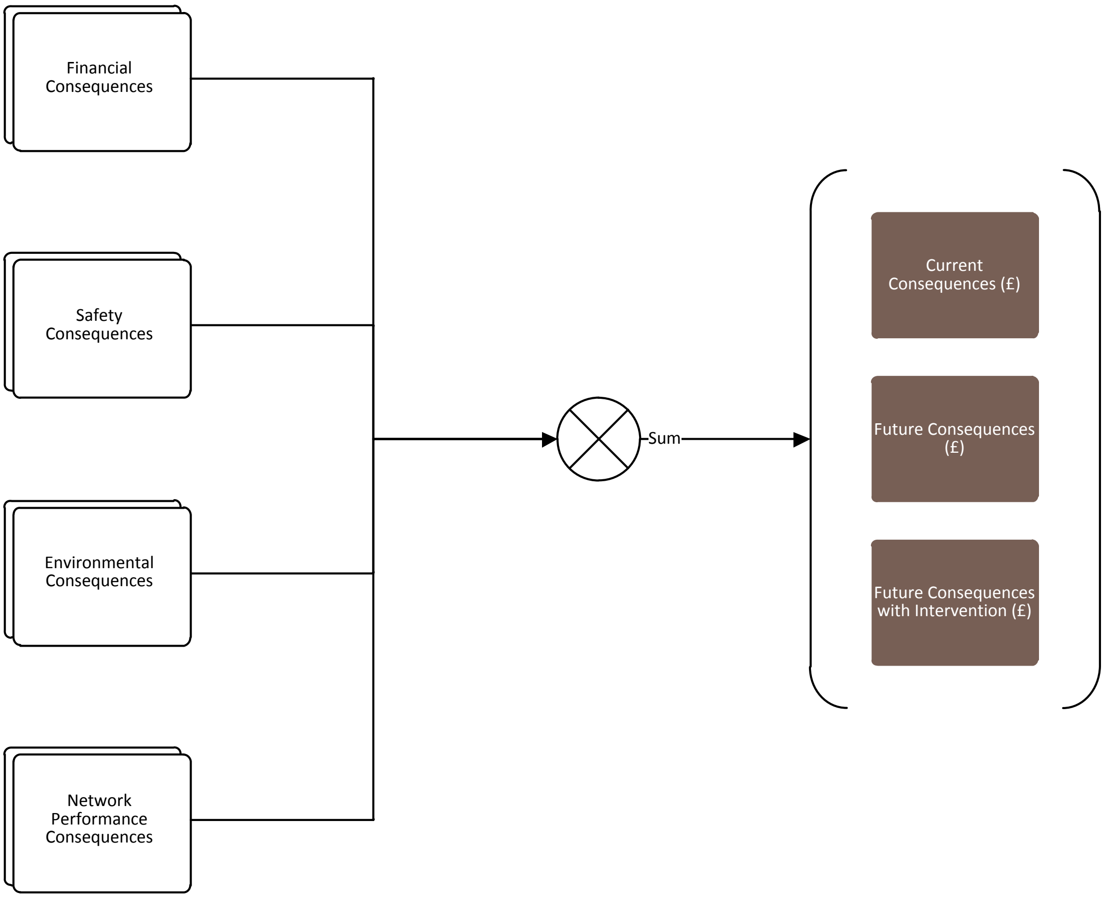

FIGURE 21: CONSEQUENCES OF FAILURE

These are the only Consequence Categories considered within the Methodology.

CoF is generally assumed to remain static over time, unless affected by investment or third party actions, hence Current Consequence and forecast Future Consequence values will generally be the same.

The calculation of CoF is based on the same failure modes as PoF, i.e. Incipient Failure, Degraded Failure and Catastrophic Failure.

The Methodology is based on the production of a Reference Cost of Failure for each asset type which represents the 'typical' effects of a failure based on DNO experience. Asset-specific costs are based on the application of specific modifying factors to these reference costs in order to reflect the costs associated with a condition-based failure of the asset in question. The reference costs and factors used within the Methodology are common for all DNOs. This process is shown in Figure 22.

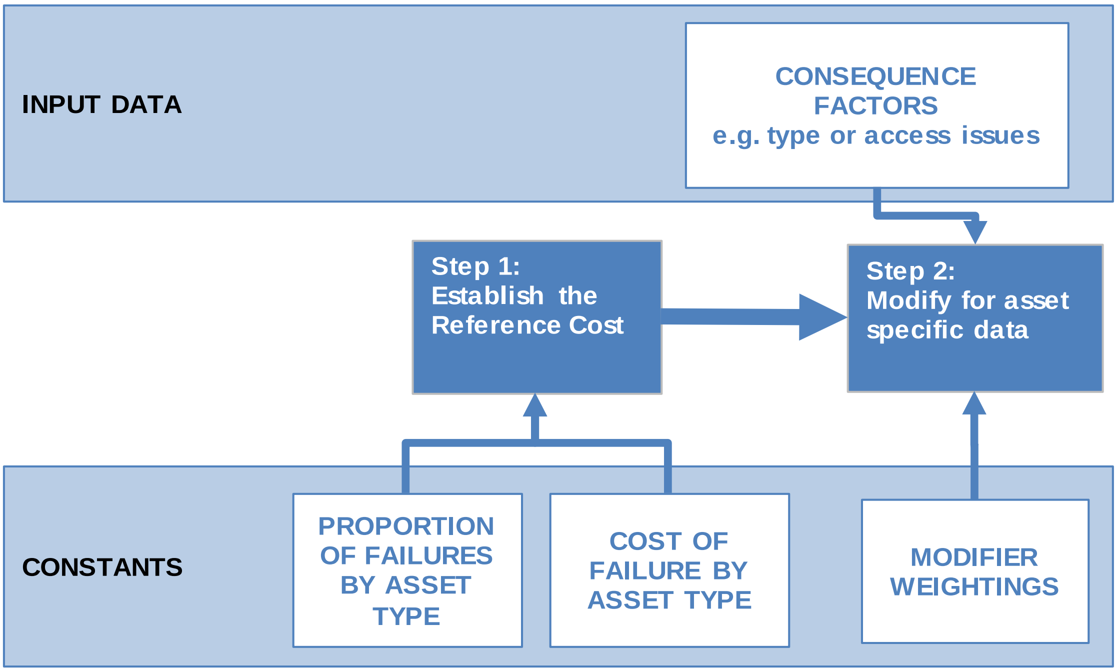

FIGURE 22: COF METHODOLOGY

The interdependence of assets in terms of Network Performance is taken into account at EHV and 132kV (typically N-1 assets) by including a factor for coincident failure in deriving the Reference Network Performance Cost of Failure. This is done by considering the Probability of a Coincident Outage (see Table 226). Other assets are assumed to be independent of one another, reflecting the radial nature of distribution networks. However, the impact of the failure of one asset on the propensity of another asset to fail is implicitly included in the observable failure rate and hence the PoF parameters (e.g. K-Value in Table 21).

7.2 Reference Costs of Failure

The following sections set out the process for the production of the Reference Costs of Failure and modifying factors for each of the four Consequence Categories within the Methodology. These costs are shown in Table 16.

TABLE 16: REFERENCE COSTS OF FAILURE

Asset Register Category	Financial	Safety	Environmental	Network Performance	Total
LV Poles	£1,113	£536	£75	£1,218	£2,942
6.6/11kV Poles	£1,592	£179	£75	£1,297	£3,143
20kV Poles	£1,910	£179	£75	£1,297	£3,461
33kV Pole	£2,053	£179	£75	£57	£2,364
66kV Pole	£3,094	£179	£75	£114	£3,462
33kV Tower	£5,618	£334	£155	£7,250	£13,357
66kV Tower	£10,527	£334	£155	£20,770	£31,786
132kV Tower	£12,172	£334	£155	£41,540	£54,201
33kV Fittings	£189	£1,336	£80	£167	£1,772
66kV Fittings	£243	£1,336	£80	£333	£1,992
132kV Fittings	£404	£1,336	£80	£666	£2,486
33kV OHL (Tower Line) Conductor	£14,811	£1,336	£80	£833	£17,060
66kV OHL Conductor	£19,644	£1,336	£80	£1,666	£22,726
132kV OHL (Tower Line) Conductor	£16,988	£1,336	£80	£3,331	£21,735
HV Sub Cable	£151,492	£2	£3,000	£160,627	£315,121
33kV UG Cable (Non Pressurised)	£26,340	£2	£605	£2,572	£29,519
33kV UG Cable (Oil)	£108	£2	£4,898	£3	£5,011
33kV UG Cable (Gas)	£264	£2	£45	£26	£337
66kV UG Cable (Non Pressurised)	£53,291	£2	£605	£5,144	£59,042
66kV UG Cable (Oil)	£116	£2	£4,898	£5	£5,021
66kV UG Cable (Gas)	£432	£2	£45	£51	£530
132kV UG Cable (Non Pressurised)	£90,934	£2	£905	£10,287	£102,128
132kV UG Cable (Oil)	£129	£2	£6,167	£10	£6,308
132kV UG Cable (Gas)	£667	£2	£67	£103	£839
EHV Sub Cable	£237,500	£2	£3,000	£2,572	£243,074
132kV Sub Cable	£400,000	£2	£3,000	£10,287	£413,289
LV Circuit Breaker	£3,388	£8,050	£18	£12,436	£23,892
LV Pillar (ID)	£4,719	£8,050	£18	£9,247	£22,034
LV Pillar (OD at Substation)	£5,136	£8,050	£18	£9,247	£22,451
LV Pillars (OD not at Substation)	£2,854	£8,504	£18	£9,247	£20,623
LV UGB	£2,854	£8,504	£71	£3,699	£15,128
LV Board (WM)	£6,520	£8,050	£18	£9,247	£23,835
LV Board (X-type Network) (WM)	£7,694	£8,050	£18	£9,247	£25,009
6.6/11kV CB (GM) Primary	£6,315	£20,771	£1,141	£9,725	£37,952

Asset Register Category	Financial	Safety	Environmental	Network Performance	Total
6.6/11kV CB (GM) Secondary	£5,792	£4,262	£1,108	£7,780	£18,942
6.6/11kV Switch (GM)	£4,384	£4,262	£1,108	£7,780	£17,534
6.6/11kV RMU	£8,190	£4,262	£1,108	£7,780	£21,340
6.6/11kV X-type RMU	£11,083	£4,262	£1,108	£7,780	£24,233
20kV CB (GM) Primary	£7,911	£20,771	£1,141	£9,725	£39,548
20kV CB (GM) Secondary	£6,005	£4,262	£1,108	£7,780	£19,155
20kV Switch (GM)	£5,081	£4,262	£1,108	£7,780	£18,231
20kV RMU	£8,343	£4,262	£1,108	£7,780	£21,493
33kV CB (Air Insulated Busbars)(ID) (GM)	£12,081	£20,771	£2,589	£24,248	£59,689
33kV CB (Air Insulated Busbars)(OD) (GM)	£14,874	£20,771	£2,589	£12,274	£50,508
33kV CB (Gas Insulated Busbars)(ID) (GM)	£18,299	£20,771	£2,589	£24,248	£65,907
33kV CB (Gas Insulated Busbars)(OD) (GM)	£18,299	£20,771	£2,589	£12,274	£53,933
33kV Switch (GM)	£8,537	£20,771	£2,589	£12,274	£44,171
33kV RMU	£21,099	£20,771	£2,589	£12,274	£56,733
66kV CB (Air Insulated Busbars)(ID) (GM)	£24,081	£20,771	£2,589	£24,248	£71,689
66kV CB (Air Insulated Busbars)(OD) (GM)	£38,500	£20,771	£2,589	£12,274	£74,134
66kV CB (Gas Insulated Busbars)(ID) (GM)	£43,431	£20,771	£2,589	£24,248	£91,039
66kV CB (Gas Insulated Busbars)(OD) (GM)	£43,431	£20,771	£2,589	£12,274	£79,065
132kV CB (Air Insulated Busbars)(ID) (GM)	£67,501	£31,968	£7,102	£128,126	£234,697
132kV CB (Air Insulated Busbars)(OD) (GM)	£31,781	£31,968	£7,102	£32,331	£103,182
132kV CB (Gas Insulated Busbars)(ID) (GM)	£140,585	£31,968	£7,102	£128,126	£307,781
132kV CB (Gas Insulated Busbars)(OD) (GM)	£140,585	£31,968	£7,102	£32,331	£211,986
6.6/11kV Transformer (GM)	£7,739	£4,262	£3,171	£4,862	£20,034
20kV Transformer (GM)	£8,811	£4,262	£3,171	£4,862	£21,106
33kV Transformer (GM)	£73,000	£20,771	£14,190	£48,197	£156,158
66kV Transformer	£112,203	£20,771	£14,190	£48,197	£195,361
132kV Transformer	£218,932	£31,968	£29,212	£255,853	£535,965

7.3 Financial Consequences

7.3.1 Overview

The Financial CoF is the cost of repair or replacement to return an asset to its pre-fault state. In the context of the Methodology, it is derived using an Asset Category Reference Financial Cost of Failure, which is then modified based on asset-specific data.

The overall process for deriving the Financial CoF is shown in Figure 23.

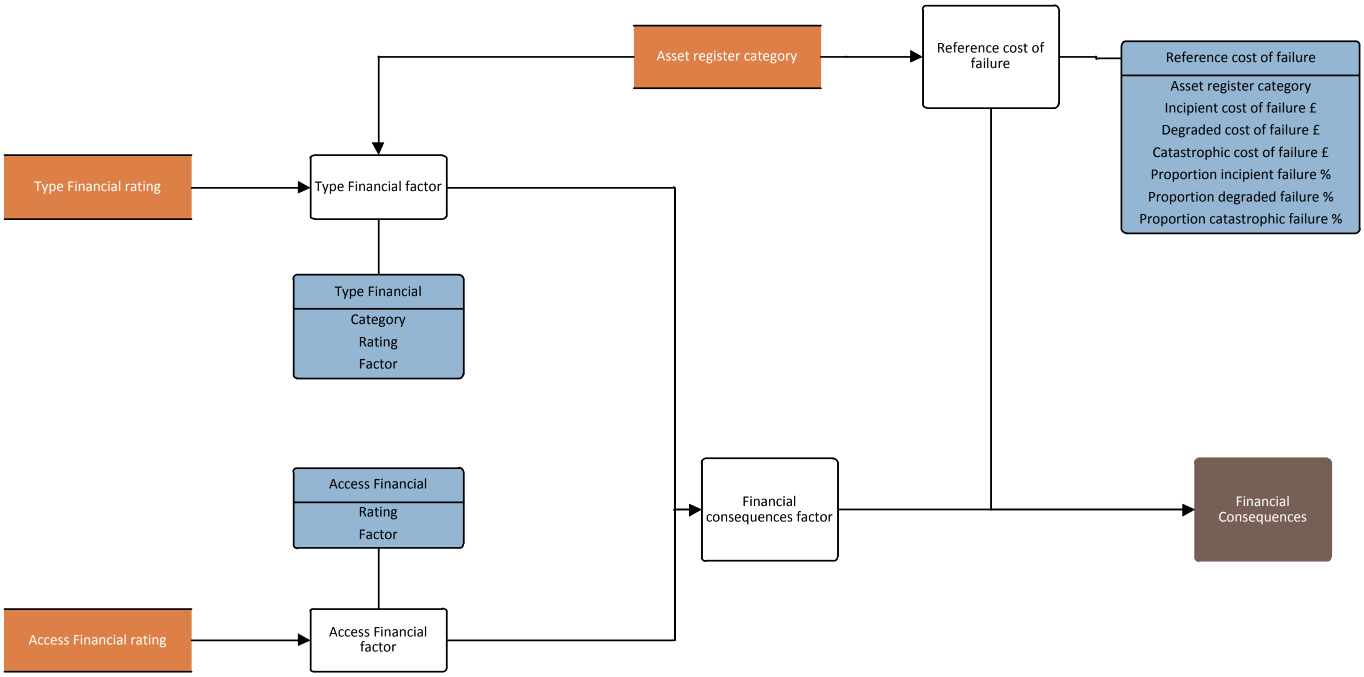

FIGURE 23: FINANCIAL COF

7.3.2 Reference Financial Cost of Failure

The Reference Financial Cost of Failure is based on an assessment of the typical replacement and repair costs incurred by a failure of the asset in each of its three failure modes; incipient, degraded and catastrophic. This assessment considers the cost of a repair in each case, and the relative proportions of failures that are associated with each failure mode, to derive a weighted average financial cost.

$$\begin{aligned}&\textbf{Reference Financial Cost of Failure} = \\&(\textbf{Proportion of Failures that are Incipient Failure} \times \textbf{Likely Cost of Incipient Failure}) \\&+ (\textbf{Proportion of Failures that are Degraded Failures} \times \textbf{Likely Cost of Degraded Failure}) \\&+ (\textbf{Proportion of Failures that are Catastrophic Failures} \times \textbf{Likely Cost of Catastrophic Failure})\end{aligned} \quad \text{(Eq. 25)}$$

The financial consequences framework has been built with reference to historic reported costs for repairs and replacement such that the values used represent the actual typical costs incurred by a DNO in returning a faulted asset to pre-fault serviceability.

Further detail, including the relative proportions of failures by failure type (incipient, degraded and catastrophic), used in the derivation of the Reference Financial Cost of Failure can be found in Table 211 in Appendix D. The Reference Financial Cost of Failure shown in this table, for the relevant Asset Category, shall be used to calculate the Financial CoF, for each asset.

7.3.3 Financial Consequences Factor

The Financial CoF can then be derived for individual assets by applying a Type Financial Factor and/or an Access Financial Factor to the Reference Financial Cost of Failure. This results in a Financial CoF that reflects the consequence characteristics of an individual asset of that type which may materially affect the cost of returning the asset to its pre-fault state, in comparison to what would be considered typical for the Asset Category.

$$\text{Financial Consequences of Failure} = \text{Reference Financial Cost of Failure} \times \text{Financial Consequences Factor} \qquad \text{(Eq. 26)}$$

Where:

$$\text{Financial Consequences Factor} = \text{Type Financial Factor} \times \text{Access Financial Factor} \qquad \text{(Eq. 27)}$$

7.3.3.1 TYPE FINANCIAL FACTOR

This Factor allows for an adjustment to be made based on considerations specific to an asset or group of assets at a sub-level of the Asset Register Category. This will typically be applied to reflect industry experience with operating specific subcategories of asset where repair and replacement costs vary from the reference cost. Lookup tables containing the criteria and values for the Type Financial Factor can be found in Table 212 in Appendix D.

7.3.3.2 ACCESS FINANCIAL FACTOR

This Factor allows for an adjustment to be made based on a consideration of access to the faulted asset, insofar as issues of access will have a direct and material influence on the scale of Financial Consequences, e.g. access to constrained sites/confined spaces. Lookup tables containing the criteria and values for the Access Financial Factor can be found in Tables 213 and 214 in Appendix D.

7.4 Safety Consequences

7.4.1 Overview

The Safety Consequences have been derived with reference to appropriate safety regulations and guidance. The guidance for the components comprising safety consequences comes from the Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002 [Ref. 6] and associated guidance from the Health and Safety Executive (HSE) [Ref. 7].

The overall process for deriving the Safety CoF is shown in Figure 24.

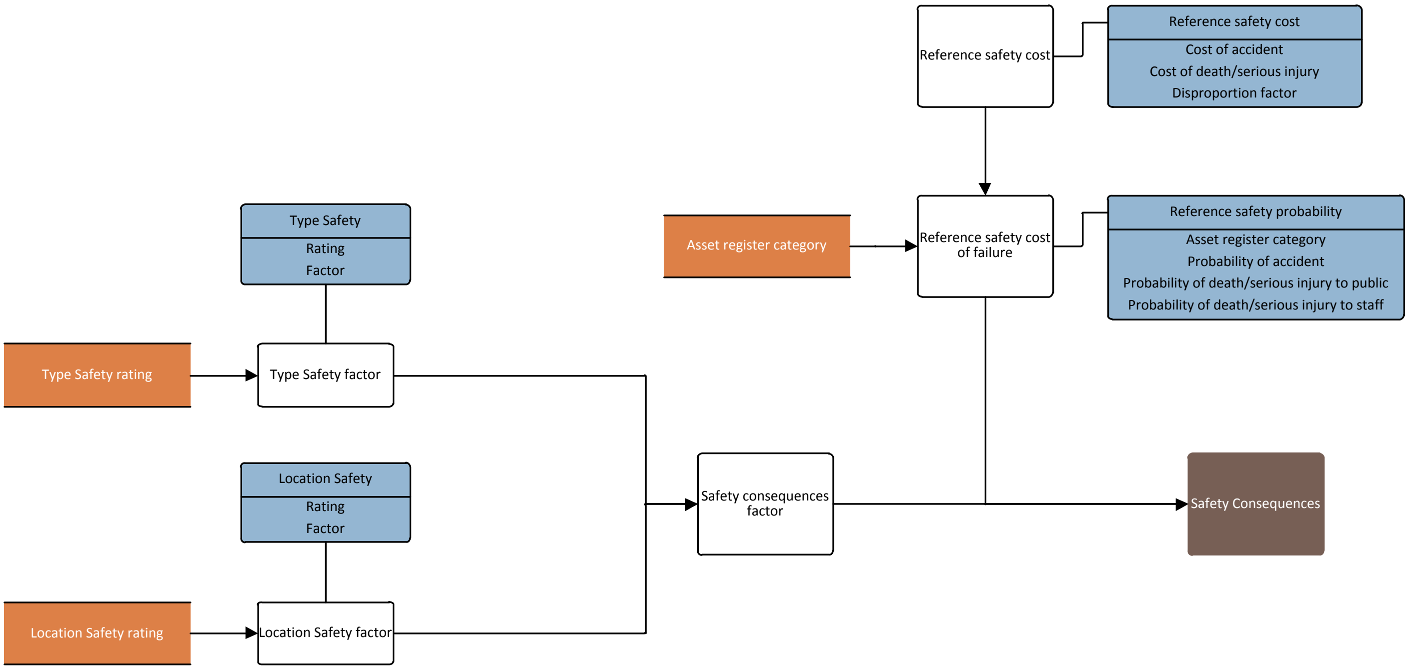

FIGURE 24: SAFETY CONSEQUENCES OF FAILURE

7.4.2 Reference Safety Cost of Failure

The Reference Safety Cost of Failure is derived initially by applying the probability that a failure could result in an accident, serious injury or fatality to the cost of a Lost Time Accident (LTA) or Death or Serious Injury (DSI) as appropriate.

$$\textbf{Reference Safety Cost of Failure} = ((\textbf{Probability of LTA} \times \textbf{Cost of LTA}) + ((\textbf{Probability of DSI to the Public} + \textbf{Probability of DSI to the Staff}) \times (\textbf{Cost of DSI})) \times \textbf{Disproportion Factor} \quad \text{(Eq. 28)}$$

Where:

- *Cost of LTA is the Reference Cost of a Lost Time Accident as shown in Table 216 in Appendix D*
- *Cost of DSI is the Reference Cost of a Death or Serious Injury as shown in Table 217 in Appendix D*
- *Disproportion Factor is explained later in this section*

Each Asset Category has an associated reference safety probability based on applying the appropriate value (of preventing a LTA or DSI) to the corresponding probability that each of these events occurs, categorised as follows:-

i) LTA;
ii) DSI to member of staff; and
iii) DSI to member of the public.

These values have been derived from an assessment of both disruptive and non-disruptive failure probabilities for these events based on bottom up assessments of faults. These have been evaluated for each Asset Category and are:-

i) probability that event could be hazardous;

ii) probability that person who is present suffers the effect; and
iii) probability that affected person is present when fault occurs.

The Reference Safety Cost of Failure uses costs for 'death or serious injury' and 'accident' that are based on the HSE's GB cross-industry wide appraisal values for fatal injuries and for non-fatal injuries [Ref. 7]. These represent a quantification of the societal value of preventing a fatality or lost time accident. The same valuation of costs for 'death or serious injury' and 'accident' has been used in the derivation of the Reference Safety Cost of Failure for all Asset Categories.

In addition, a Disproportion Factor recognising the high risk nature of the electricity distribution industry is applied. Such factors are described by the HSE guidance when identifying reasonably practicable costs of mitigation [Ref. 8]. This value is not mandated by the HSE but they state that they believe that "the greater the risk, the more should be spent in reducing it, and the greater the bias should be on the side of safety". They also suggest that the extent of the bias must be argued in the light of all the circumstances and that the factor is unlikely to be higher than 10. In the Methodology, the factor is set to 6.25 (see Table 217), which serves to cap the current value of preventing a fatality at £10m.

This work aligns to risk analysis carried out within the HSE's "Tolerability of Risk" (ToR) framework [Ref. 9].

Further detail including the probabilities of Lost Time Accidents and Death or Serious Injury and the values for Reference Safety Cost can be found in Appendix D. The cost of an LTA and the cost of a DSI are common for all asset types.

7.4.3 Safety Consequences Factor

The Methodology includes the ability to vary the Safety CoF for an individual asset around the Reference Safety Cost of Failure for its type, based on a consideration of two additional factors; the Type Safety Factor and the Location Safety Factor. These are designed to capture the specific circumstances of individual assets insofar as they are likely to have a material impact on the safety consequences of any failure of the asset and are applied as a combined Safety Consequences Factor to the Reference Safety Cost of Failure. This is shown in Eq. 29.

$$\text{Safety Consequences of Failure} = \text{Reference Safety Cost of Failure} \times \text{Safety Consequences Factor} \quad \text{(Eq. 29)}$$

Where:

- *The Safety Consequences Factor is derived using a lookup value from the location/type matrix shown in Tables 218 & 219, applying the criteria shown in Section D.2 of Appendix D.*

The requirement to undertake assessments of this type is stated in the ESQCR and the guidance below is adapted from the guidance associated with the regulations.

7.4.3.1 TYPE SAFETY FACTOR

This addresses the principal characteristics of the equipment and its particular siting.

This can include reflection of the “Nature and situation of equipment” category within the ESQCR risk assessment. Generally, equipment comprising exposed conductors will be higher risk in view of the consequences of persons coming into contact with that equipment. Plant which is fully insulated or metal enclosed will generally be lower risk. Equipment or plant which is likely to be attractive to vandals or thieves (e.g. terminal Towers) will generally be higher risk than plant which is less attractive to such persons (e.g. single wood poles).

Another characteristic considered for switchgear is the interruption medium and arc flash protection as oil filled switchgear failures can be explosive.

7.4.3.2 LOCATION SAFETY FACTOR

This is taken from the “Nature and situation of surrounding land” test in the ESQCR risk assessment. Here duty holders are required to take a view of the risk of danger from interference with the equipment - whether wilful or accidental - in consideration of the environment in which the equipment is placed.

There are two aspects to this test: firstly the geography of the land and its features (for example forests, rivers, flat fields, motorway, city streets) and secondly the use of the land (for example agricultural machinery, recreational areas, schools, housing estate).

For example electrical equipment in housing estates or in close proximity to unsupervised recreational playing fields will generally be at higher risk of danger from interference than equipment situated on sparsely populated land or contained within occupied premises.

7.5 Environmental Consequences

7.5.1 Overview

The Environmental Consequences have been derived with reference to appropriate environmental regulations and stakeholders.

The overall process for deriving the Environmental CoF is shown in Figure 25.

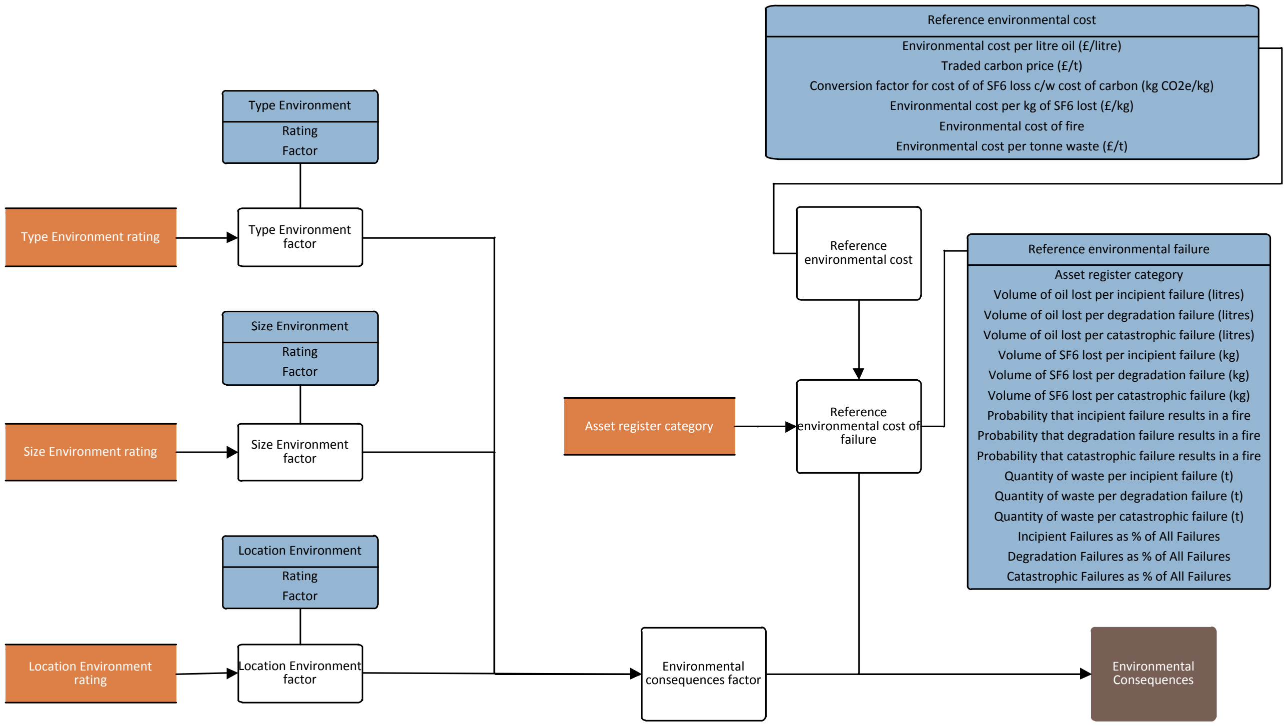

FIGURE 25: ENVIRONMENTAL CONSEQUENCES OF FAILURE

7.5.2 Reference Environmental Cost of Failure

The Environmental CoF value for an asset is derived using a Reference Environmental Cost of Failure, which is modified for individual assets using asset-specific factors. This is based on an assessment of the typical environmental impacts of a failure of the asset in each of its three failure modes; incipient, degraded and catastrophic. The Reference Environmental Cost of Failure that shall be used for each Asset Category is shown in Table 220 in Appendix D.

This assessment considers four factors;

i) Volume of oil lost;
ii) Volume of SF_6 lost;
iii) Probability of the event leading to a fire; and
iv) Quantity of waste produced.

$$\begin{aligned}&\textbf{Reference Environmental Cost of Failure} = \\ &(\textbf{\% of Incipient Failures}) \times ((\textbf{Volume of oil lost per Incipient failure} \times \\ &\textbf{Environmental cost per litre oil } (\pounds/\text{litre})) + (\textbf{Volume of SF}_6 \textbf{ lost per Incipient failure} \times \\ &\textbf{Environmental cost per kg of SF}_6 \textbf{ lost } (\pounds/\text{kg})) + \\ &(\textbf{Probability of failure leading to a fire per Incipient failure} \times \textbf{Environmental cost of fire}) + \\ &(\textbf{Quantity of waste produced per incipient failure} \times \textbf{Environmental cost per tonne waste } (\pounds/\text{t}))) + \\ &(\textbf{\% of Degraded Failures}) \times ((\textbf{Volume of oil lost per Degraded failure} \times \\ &\textbf{Environmental cost per litre oil } (\pounds/\text{litre})) + (\textbf{Volume of SF}_6 \textbf{ lost per Degraded failure} \times \\ &\textbf{Environmental cost per kg of SF}_6 \textbf{ lost } (\pounds/\text{kg})) + \\ &(\textbf{Probability of failure leading to a fire per Degraded failure} \times \textbf{Environmental cost of fire}) + \\ &(\textbf{Quantity of waste produced per Degraded failure} \times \textbf{Environmental cost per tonne waste } (\pounds/\text{t}))) + \\ &(\textbf{\% of Catastrophic Failures}) \times ((\textbf{Volume of oil lost per Catastrophic failure} \times \\ &\textbf{Environmental cost per litre oil } (\pounds/\text{litre})) + (\textbf{Volume of SF}_6 \textbf{ lost per Catastrophic failure} \times \\ &\textbf{Environmental cost per kg of SF}_6 \textbf{ lost } (\pounds/\text{kg})) + \\ &(\textbf{Probability of failure leading to a fire per Catastrophic failure} \times \textbf{Environmental cost of fire}) + \\ &\textbf{Quantity of waste produced per Catastophic failure} \times \textbf{Environmental cost per tonne waste } (\pounds/\text{t})))\end{aligned} \quad \text{(Eq. 30)}$$

Where:

- *Environmental cost per litre oil = £36.08/litre*
- *Environmental cost per kg of SF_6 lost = £240/kg*
  Which is derived from:
  - *Traded carbon price = £10.04/tonne*
  - *Cost of SF_6 loss c/w cost of carbon = 23,900kg(CO_2)/kg*
- *Environmental cost of fire = £5,000*
- *Environmental cost per tonne waste = £150/tonne*

The sources for the above costs are shown in Table 17.

TABLE 17: SOURCES OF INFORMATION FOR ENVIRONMENTAL REFERENCE CASE

Fixed value	Source
Environmental cost per litre oil (£/litre)	This is derived from the EU trading value for carbon emissions and is consistent with the value used in Ofgem's RIIO-ED1 Cost Benefit Analysis template (used for the RIIO-ED1 submissions) (at 2012/13 prices)
Traded carbon price (£/t)	https://www.gov.uk/carbon-valuation (note: 2016 to 2030 DECC's updated traded sector carbon values published Oct 2012, 2031 onwards based on DECC carbon values published Oct 2011.) http://www.defra.gov.uk/publications/2012/05/30/pb13773-2012-ghg-conversion/ (note: figures taken from 2012 Guideline to Defra / DECC's GHG conversion factors for company reporting, 'new 2010' factor annex 3 table 3(c).
Conversion factor for cost of SF_6 loss c/w cost of carbon (kg CO_2e/kg)	2011/12 Defra conversion factor (at 2012/13 prices)

7.5.3 Environmental Consequences Factors

The Methodology includes the ability to vary the Environmental Consequences value for an individual asset around the Reference Environmental Cost of Failure for its type, based on a consideration of three additional factors; the Type Environmental Factor, the Size Environmental Factor and the Location Environmental Factor. These are designed to capture the specific circumstances of individual assets insofar as they are likely to have a material impact on the Environmental Consequences of any failure of the asset and are applied as a combined Environmental Consequences Factor on the Reference Environmental Cost of Failure.

$$\text{Environmental Consequences of Failure} = \text{Reference Environmental Cost of Failure} \times \text{Environmental Consequences Factor} \quad \text{(Eq. 31)}$$

Where:

$$\text{Environmental Consequences Factor} = \text{Type Environmental Factor} \times \text{Size Environmental Factor} \times \text{Location Environmental Factor} \quad \text{(Eq. 32)}$$

7.5.3.1 TYPE ENVIRONMENTAL FACTOR

This Factor allows for an adjustment to be made based on considerations specific to an asset or group of assets at a sub-level of the Asset Register Category. As the Reference Environmental Cost of Failure is built up using the impact from oil & SF_6 the Type Environmental Factor is used to temper the effects for each switchgear type. The modifier values for the Type Environmental Factor can be found in Table 221 in Appendix D.

7.5.3.2 SIZE ENVIRONMENTAL FACTOR

This Factor allows for an adjustment to be made based on a consideration of the size of the asset in question, insofar as the size has a direct and material influence on the scale of Environmental Consequences, e.g. a larger than average Transformer holding a greater quantity of oil than that assumed in the reference case for that asset type. The modifier values for the Size Environmental Factor can be found in Table 222 in Appendix D.

7.5.3.3 LOCATION ENVIRONMENTAL FACTOR

This Factor allows for an adjustment to be made based on an assessment of the environmental sensitivity of the site on which an asset is located. The specific concerns will vary by asset type but include proximity to watercourses and other environmentally sensitive areas. The Factor also recognises any mitigation associated with the asset. The modifier values for the Location Environmental Factor can be found in Table 223 in Appendix D. This Factor is derived by combining separate Factors relating to proximity to a watercourse (Proximity Factor) and the presence of a bund (Bunding Factor) as shown in Eq. 33.

$$\text{Location Environment Factor} = \text{Proximity Factor} \times \text{Bunding Factor} \quad \text{(Eq. 33)}$$

7.6 Network Performance Consequences

7.6.1 Overview

The Network Performance CoF for an asset is derived from one of two approaches, depending on the voltage of the asset considered. For all assets operating at 20kV and below, the LV & HV Asset Consequences process is followed. For all assets operating above 20kV, the EHV & 132kV Asset Consequences process is followed.

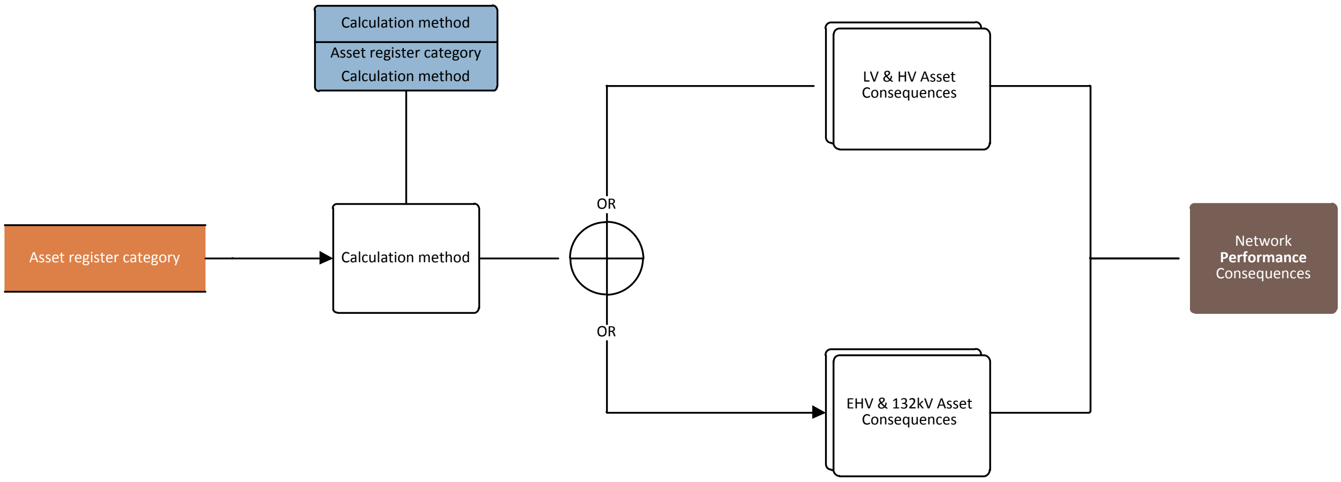

FIGURE 26: NETWORK PERFORMANCE CONSEQUENCES OF FAILURE

7.6.2 Network Performance Consequences (LV & HV)

For LV and HV assets, a Reference Network Performance Cost of Failure appropriate to the Asset Category is initially applied. The resulting value can then be modified for individual assets in two ways:-

i) directly, based on the ratio of customers connected to an individual asset to the equivalent figure used in the average value; and/or

ii) via the application of a Customer Sensitivity Factor to reflect particular customer characteristics (if appropriate).

Applying these Factors results in an LV or HV Asset Consequence value that reflects the network consequence characteristics of an individual asset of that type.

The overall process for deriving the Network Performance CoF is shown in Figure 27.

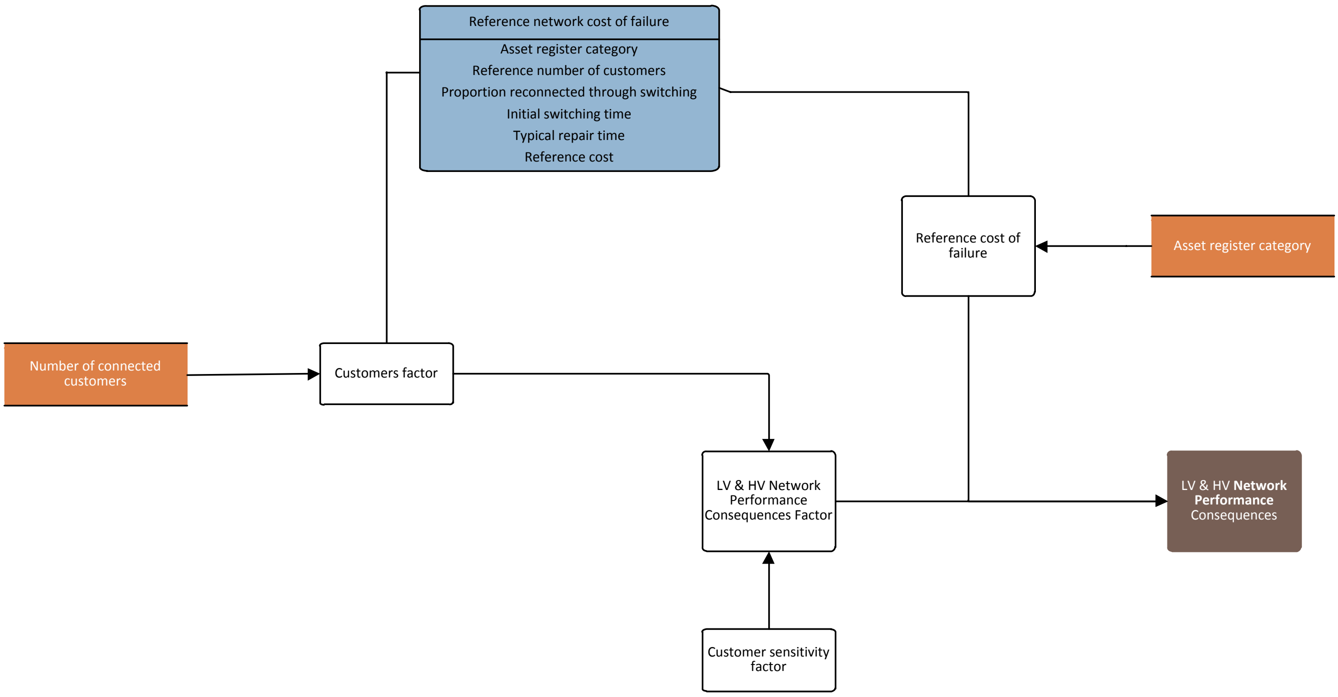

FIGURE 27: NETWORK PERFORMANCE ASSET CONSEQUENCES OF FAILURE (LV & HV)

7.6.2.1 REFERENCE NETWORK PERFORMANCE COST OF FAILURE (LV & HV)

The Reference Network Performance Cost of Failure is based on an assessment of the typical network costs incurred by a failure of the asset as measured through its impact in relation to the number of customers interrupted and the duration of those interruptions. For regulatory purposes, this is captured via the IIS mechanism.

An assessment is made of the typical numbers of customers interrupted by a failure, and the typical time to restore all supplies. This is based on a typical number of customers being connected to the section of distribution network that would be affected by failure of the asset (the Reference Number of Connected Customers).

The numbers of customers interrupted and customer minutes without supply are evaluated and multiplied by the relevant cost of a customer interruption (Cost of CI) and cost of a customer minute lost (Cost of CML) to produce a typical cost per failure for a given Reference Number of Connected Customers.

$$\begin{aligned}&\textbf{Reference Network Performance Cost of Failure} = \\ &[(\textbf{Cost of CML} \times 60 \times \textbf{Reference Number of CC} \times \textbf{Switching Time} \times (100\% \\ &\qquad - \%\ \textbf{of CC restored through immediate switching})) \\ &+ (\textbf{Cost of CML} \times 60 \times \textbf{Reference Number of CC} \times \textbf{Restoration Time} \times (100\% - \\ &\%\ \textbf{of CC restored after manual switching})) \\ &+ (\textbf{Cost of CI} \times \textbf{Reference Number of CC} \times (100\% - \\ &\%\ \textbf{of CC restored through immediate switching}))] \times \%\ \textbf{of failures that result in} \\ &\textbf{interruption to supply}\end{aligned} \quad \text{(Eq. 34)}$$

Where:

- *CC = Connected Customers*
- *Switching Time and Restoration Time are durations (in hours)*

Further explanation on the derivation of the values for the Reference Network Performance Cost of Failure (LV & HV) can be found in section D.4.1 in Appendix D. The values of Reference Network Performance Cost of Failure (LV & HV) by Asset Category can be found in in Appendix D.

7.6.2.2 NETWORK PERFORMANCE FACTORS (LV & HV)

The Reference Network Performance Cost of Failure can then be modified on an asset by asset basis as shown in Eq. 35.

$$\begin{aligned}&\textbf{Network Performance Cost of Failure} =\\&\textbf{Reference Network Performance Cost of Failure} \times\\&\textbf{Network Performance Consequence Factor}\end{aligned}$$ (Eq. 35)

Where:

$$\begin{aligned}&\textbf{Network Performance Consequence Factor}\\&\qquad = \textbf{Customer Factor} \times \textbf{Customer Sensitivity Factor}\end{aligned}$$ (Eq. 36)

Customer Factor

This Factor is used to reflect the number of customers impacted by failure of an individual asset, relative to the reference number of customers used in the derivation of the Reference Network Performance Cost of Failure.

This is applied as a direct Factor, i.e. not via a lookup table. For example, if the number of customers used in the derivation of the Reference Network Performance Cost of Failure is 100, but for a specific example it is 80 (or 120), then a modifying factor of 0.8 (or 1.2) would be applied.

$$\textbf{Customer Factor} = \frac{\textbf{No. of Customers}}{\textbf{Reference No. of Customers}}$$ (Eq. 37)

Where a DNO identifies that the customers fed by an individual asset have an exceptionally high demand per customer, then the No. of Customers used in the derivation of Eq. 37 may be derived by applying an adjustment to the actual number of customers fed by the asset as shown in Table 18. This adjustment recognises that for high demand customers the cost of a customer interruption and a customer minute lost may not reflect the value of lost load to the customer. DNOs can elect whether or not to apply this adjustment within their implementation of the Methodology.

TABLE 18: CUSTOMER NUMBER ADJUSTMENT FOR LV & HV ASSETS WITH HIGH DEMAND CUSTOMERS

Maximum Demand on Asset / Total Number of Customers fed by the Asset (kVA per Customer)	No. of Customers to be used in the derivation of Customer Factor
< 50	1 x actual number of customers fed by the asset
≥ 50 and < 100	25 x actual number of customers fed by the asset
≥ 100 and < 500	100 x actual number of customers fed by the asset
≥ 500 and < 1000	250 x actual number of customers fed by the asset
≥ 1000 and < 2000	500 x actual number of customers fed by the asset
≥ 2000	1000 x actual number of customers fed by the asset

The default value for the Customer Factor is 1.

Customer Sensitivity Factor

The Customer Sensitivity Factor is used to reflect circumstances where the customer impact is increased due to customer reliance on electricity (e.g. vulnerable customers). DNOs may use this factor at their discretion in order to modify the Network Performance Consequence Factor.

The default value for the Customer Sensitivity Factor is 1. Individual DNOs are provided with the freedom within the Methodology to apply a Customer Sensitivity Factor, other than the default, to the Network Performance Consequences (LV & HV) for any asset, provided that:-

i) the individual DNO documents all instances where a Customer Sensitivity Factor different from the default is applied within their individual Network Asset Indices Methodology; and
ii) The Customer Sensitivity Factor shall not be less than 1, nor greater than 2.

7.6.3 Network Performance Consequences (EHV & 132kV)

Similarly for EHV and 132kV assets, asset-specific Network Performance Consequence Factors are applied to the Reference Network Performance Cost of Failure in order to calculate the Network Performance Consequences associated with an individual asset.

For these assets, the Methodology reflects the fact that redundancy is usually designed into networks at these voltages due to the size of demand group they supply.

A significant proportion of these networks are constructed so that the supply to customers is secure for a single outage of any circuit within the network. For the purposes of the Methodology a network shall be considered secure if, in the event of a first circuit outage, there is either no interruption of supply to customers or supply is restored immediately through automatic switching as defined in ENA Engineering Recommendation P2/6 (‘Security of Supply’).

Once a first circuit outage has occurred within a secure network, there may be parts of the network that would experience a loss of supply if a further circuit outage were to occur. The load that could be expected to be impacted (i.e. would experience a loss of supply) during such a further circuit outage is referred to as Load at Risk.

Within EHV and 132kV networks, there may also be some parts of the network where the supply to customers is not secure for a first circuit outage event. In such cases, a first circuit outage will directly impact any connected customers and restoration is achieved via switching in line with the timescales specified in Engineering Recommendation P2/6 for that demand group.

The methodology for determining Network Performance Consequences for EHV and 132kV assets enables both these types of network to be recognised.

The overall process for deriving the Network Performance Cost of Failure is shown in Figure 28.

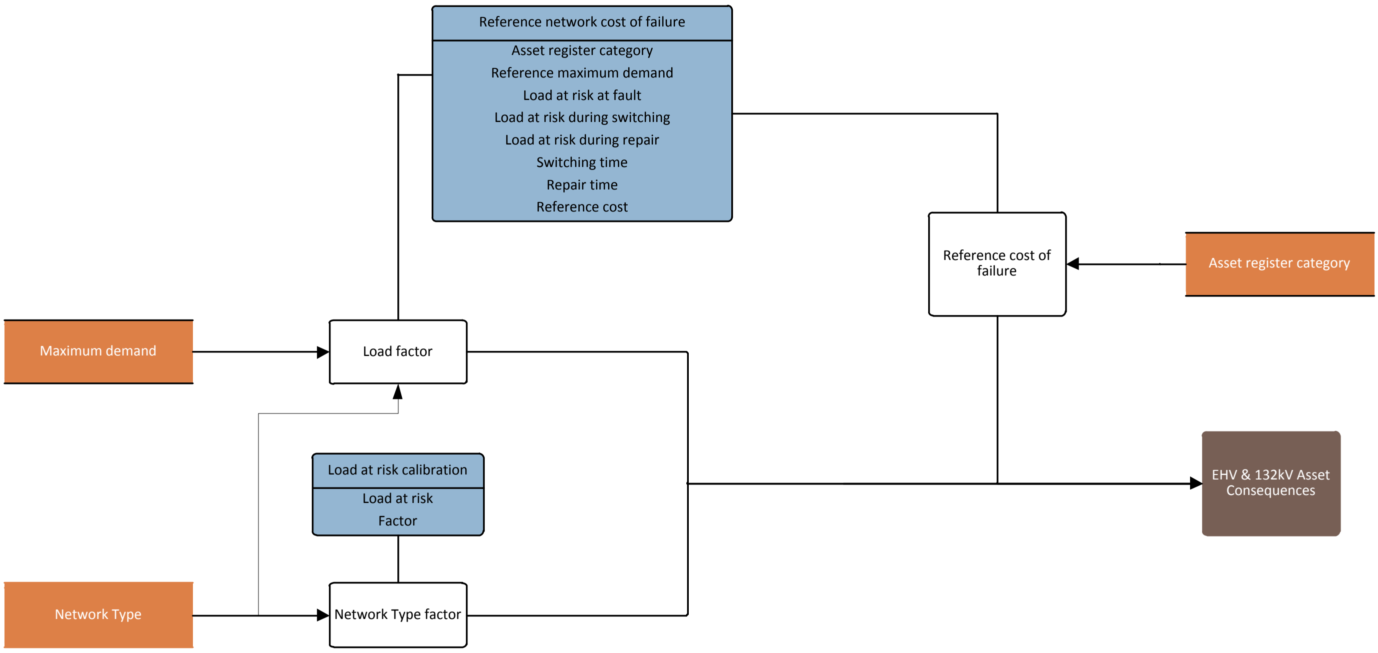

FIGURE 28: NETWORK PERFORMANCE CONSEQUENCES OF FAILURE (EHV & 132KV)

7.6.3.1 REFERENCE NETWORK PERFORMANCE COST OF FAILURE (EHV & 132KV)

The Reference Network Performance Cost of Failure is based on an assessment of the amount of Load at Risk during three stages of failure, and the typical duration of each stage:

i) During fault (T1): this is the time period between initial circuit protection trip operation and automatic switching to reconfigure the network;
ii) During initial switching (T2): this is the time period during which further manual network switching is undertaken to reconfigure the network to minimise the risk associated with a further circuit outage; and
iii) During repair time (T3).

The Load at Risk is evaluated based on a typical value of maximum demand under normal running conditions.

The load at risk is then multiplied by the relevant Value of Lost Load (VoLL) figure to derive a typical Reference Network Performance Cost of Failure for these assets, taking account of the probability of a further circuit outage.

$$\begin{aligned}&\textbf{Reference Network Performance Cost of Failure} = \\&\big((\textbf{Load at risk in T1} \times \textbf{Duration of T1}) + (\textbf{Load at risk in T2} \times \textbf{Duration of T2}) + \\&(\textbf{Load at risk in T3} \times \textbf{Duration of T3})\big) \times \textbf{\% of failures that result in an unplanned outage} \times \\&\textbf{Probability of further coincident outage} \times \textbf{VoLL}\end{aligned} \quad \text{(Eq. 38)}$$

The value of VoLL used is consistent with the values for Cost of CI and Cost of CML used in the evaluation of the Reference Network Performance Cost of Failure for LV and HV assets. Therefore the evaluation of the Reference Network Performance Cost of Failure for EHV and 132kV assets is consistent with the evaluation of the impact in distribution assets.

Further explanation of the derivation of the Reference Network Performance Cost of Failure for EHV and 132kV assets can be found in Section D.4.2 in Appendix D.

7.6.3.2 NETWORK PERFORMANCE FACTORS (EHV & 132KV)

The Network Performance CoF is derived on an asset by asset basis as shown in Eq. 39.

$$\text{Network Performance Consequences of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Load Factor} \times \text{Network Type Factor} \quad \text{(Eq. 39)}$$

Load Factor

This Factor allows for the Network Performance CoF to reflect the actual load at risk associated with the failure of the asset under consideration, relative to the value of maximum demand used to create the reference value.

The Load Factor is determined as shown in Eq. 40 (i.e. not via a lookup table).

$$\text{Load Factor} = \frac{\text{Actual Load at Risk Associated with the Failure of the Asset Under Consideration}}{\text{Maximum Demand Used To Derive Reference Network Performance Cost of Failure}} \quad \text{(Eq. 40)}$$

For example, if the Reference Network Performance Cost of Failure has been derived using a reference maximum demand of 12MVA, but for a specific asset the actual load at risk was 6MVA then a Load Factor of 0.5 would be applied.

The values of maximum demand used in derivation of the Reference Network Performance Cost of Failure can be found in Table 226 in Appendix D.

Where the actual load is not known, the default value for Load Factor is dependent on the security of supply of the associated network.

A default Load Factor of 0.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A default Load Factor of 1 shall apply to assets in secure networks or where the security of the network is unknown.

Network Type Factor

This Network Performance CoF is derived on an asset by asset basis by the application of a Network Type Factor to take account of the security of supply afforded by the topology of the network in which the individual asset is located.

A Network Type Factor of 2.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A Network Type Factor of 1 shall apply to assets in secure networks.

The default value for Network Type Factor is 1.

8. REFERENCES

8.1 A Note on Referencing

The content in many of the tables consists of factors and values which were decided (by agreement or by calculation) by internal working group agreement. There are also a number of table values determined by the RIGs. Where the values have been dictated otherwise or by external sources there is an associated numbered reference.

This section of the document lists the external references and explains which tables require an external reference. It also describes, where that is not the case, what is meant by the reference to an "internal working group agreement".

8.2 Reference to Internal Working Group Agreement

Decisions governing these values were made during a model calibration exercise in 2015 which pragmatically captured engineering experience and reliability based concepts. Every table in the document was fully examined and discussed by the group.

The choice of the factors themselves came from DNO shared information about what factors existed in their current CBRM models. These models were built within the DNOs over the previous two decades. The principles guiding the decision included ensuring that DNOs collecting more information than others were not held back from continuing to do so, and to avoid duplication of factors that in essence indicated the same degradation mechanism.

The parameters for combination were also agreed collectively based on similar principles, so that while DNOs collecting more information than others should not be prevented from using their better information, DNOs collecting less should not be put in a position of not being able to achieve the kinds of Health Scores that accurately described their poorest assets. Hence the use of an MMI approach. The number of factors that can be combined also related to the number of existing factors for an asset category.

In terms of calibrating the weightings, experience with current models was drawn upon in situations where the combination method was the same as that for common methodology. The results of testing were then used so that if entire populations were tending to bias at one extreme, the weightings were revised to make sure that they resulted in a spread that was reasonable.

8.3 Table Reference Breakdown

Tables 1 to 3 summarise asset categories governed by the RIGs. This is referred to in the descriptive text above the tables.

The failure type descriptions in Table 4 were agreed by the working group.

Tables 5 and 6 show the PoF bandings and were agreed by the working group. The calibration exercise for these considered the speed at which an asset moves through each band and judged that against engineering experience.

Table 7 shows the CoF bandings. It is governed by the RIGs and comes out of previous work by the Asset Health and Criticality working group that was incorporated in the RIGs for the RIIO-ED1 business plan submissions.

Tables 8 to 15 show PoF factors for each of location, duty and condition; and parameter information for combining these factors within the methodology. These values were agreed by the working group.

Tables 16 to 18 relate to CoF. Table 16 is merely a summary of the Reference Costs of Failure which are described in detail in the Appendix D tables. As CoF values are very much governed by external sources of information there are appropriate references to these in the descriptive text along with Table 17 which explicitly lists the environmental sources. Table 18 shows customer bandings agreed by the working group.

Table 19 shows Functional Failure Definitions agreed by the working group. In this case agreement was based on an information gathering exercise across the DNOs of failure information derived from risk management over many years, including failure modes and effects analysis and a familiarity with the history of defects and faults for each asset category.

Table 20 summarises asset lives as agreed by the working group following an information sharing exercise. Where there was a wide range in the same asset category the group looked at the mix of asset types that was driving the difference and determined appropriate sub-types accordingly. Work on asset lives was carried out in substantial detail in DNOs going back to before DPCR4 and they have been used and updated in annual RRP submissions during DPCR5 and RIIO-ED1.

Table 21 shows PoF curve parameters which were calculated by the working group. Their derivation is described in Section 6.1.2 and they come from shared DNO data consisting of the observed number of functional failures for each asset category per annum, taking into account Incipient, Degraded and Catastrophic Failures; from the 2014/15 Health Index distributions; and from the total volumes of assets within the population.

Tables 22 to 33 show location and Duty Factors and calibrations agreed by the working group.

Tables 34 to 195 show Observed Condition and Measured Condition Factors and calibrations which were agreed by the working group. The decisions for these were based on a combination of obvious logical rules, engineering experience, and testing using the common methodology spreadsheet models. The obvious logical rules are that:-

i) The maximum factor value will not push the Current Health Score above its cap of 10;
ii) Weightings reflect condition so that, for example, a poor state will have a higher weighting than a moderate state for example;
iii) The distance between two states describe the engineering conditions so for example, if corrosion indicating structural damage is much more serious than corrosion indicating cosmetic damage then the weightings have a proportionate distance between them.
iv) The number of states is calculable and meaningful and in sync with DNO data collection.
v) Improvement factors are also appropriate in situations where signs of wear would have been expected indicating a Health Score better than initially indicated from age and expected life.
vi) There should be a spread across Health Index bands within a representative asset population.

For the measured condition factor values it was also recognised that the condition criteria tends to be a function of how results from the test equipment are categorised in practice. For example partial discharge typically might have a high, medium and low result.

Tables 196 to 208 relate to transformer oil sampling and are covered by external references 3 to 5.

Table 209 is for the Ageing Reduction Factors and the basis for these is covered by reference 2.

Table 210 in Appendix C is covered by the RIGs working group for the categories and the working group agreed what HI factors were affected by the intervention.

Tables 211 to 216 in Appendix D show the Criticality Factors, their Reference Cost of Failure values, and how asset specific factors are weighted. Environmental, Safety and Network Performance Consequence Factors and criteria reference external sources as is already well described in Section 7. Financial Consequence Factors came from working group agreement based on an understanding of the Financial Factors at play in practice in the different DNOs.

The reference values are derived as described in Section 7 so the tables just show the results of calculations carried out using the externally given costs and the working group agreed assumptions about derivation.

Calibration decisions for the asset specific factors were made collectively by the working group, based on the logic that as things get more critical their weightings increase in a way that is proportionate to the underlying engineering criticality being described.

8.4 Document References

1. RIIO-ED1 regulatory instructions and guidance: Annex A – Glossary https://www.ofgem.gov.uk/ofgem-publications/95310/annexaglossary-pdf
2. Reliability Centred Maintenance, John Moubray, 1991, Butterworth Heinemann.
3. BS EN 60422:2013 “Mineral insulating oils in electrical equipment — Supervision and maintenance guidance”
4. Expert System for Assessing Transformer Condition, EA Technology Report No. 4969, Project S0446, (M Black, J R Brailsford, D Hughes & M I Lees Sept 1999)
5. BS EN 60599:1999 “Mineral oil-impregnated electrical equipment in service — Guide to the interpretation of dissolved and free gases analysis”
6. Electricity Safety, Quality and Continuity Regulations 2002, as amended in 2006 (ESQCR). http://www.legislation.gov.uk/uksi/2002/2665/contents/made
7. Current HSE cost models. http://www.hse.gov.uk/statistics/cost.htm
8. Current guidance about what should and should not be considered in a duty holder’s cost benefit analysis (CBA) for health and safety ALARP determinations. http://www.hse.gov.uk/risk/theory/alarpcheck.htm
9. Reducing risks, protecting people - HSE’s decision-making process (first published in May 1999). http://www.hse.gov.uk/risk/theory/r2p2.pdf

APPENDIX A
FUNCTIONAL FAILURE DEFINITIONS

TABLE 19: FUNCTIONAL FAILURE DEFINITIONS

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
LV Circuit Breaker	Measure and break unsafe levels of current (over current), make load current, and provide a point of electrical isolation.	Failing to open on a fault. Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions). Opens Spuriously under normal conditions. Opens Intermittently (Faulty).	Failure of Housing. Disruptive Failure Resulting from Insulation Breakdown.	Nuisance tripping or failure to operate when required due to: - damage to contacts - loose internal connections -Damage to mechanism and drive rods.	Nuisance tripping or failure to operate when required due to: - Maladjusted linkage.	Failure of protection module. Failure of SCADA.
LV Pillar (ID) LV Pillar (OD at Substation / LV Pillar (OD not at a Substation)	Provide a number of points of access to LV Cable Systems for electrical connection, isolation and flexibility with network reconfiguration. Depending on the complexity of pillar they may also offer monitoring and protection (fuse or circuit breaker) capabilities.	Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions).	Failure of Housing. Disruptive Failure Resulting from Insulation Breakdown requiring the replacement of one or all ways.	Failure of Housing requiring repair. Nuisance tripping or Failure of an LV Pillar's Fuse, MCB or RCBO to operate when required due to: - deteriorated fuse carriers - breaker stuck closed.	Nuisance tripping or Failure of an LV Pillar's Fuse, MCB or RCBO to operate when required due to: - incorrect fuse/breaker rating - breaker not latching closed.	Contact damage due to incorrect operation of board.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
LV Board (WM)	Provide a number of points of access to LV Cable Systems for electrical connection, isolation and flexibility with network reconfiguration. Depending on the complexity of LV Board, they may also offer monitoring and protection (fuse or circuit breaker) capabilities.	Failing to open on a fault. Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions). Opens Spuriously under normal conditions. Opens Intermittently (Faulty).	Disruptive Failure Resulting from Insulation Breakdown.	Nuisance tripping or failure to operate when required due to: - damage to contacts - moisture ingress - deteriorated fuse carriers.	Nuisance tripping or failure to operate when required due to: - damage to contacts - loose internal connections - failure of protection module.	Failure of housing. Contact Damage due to Incorrect operation of Board.
LV UGB	Provide a number of points of access to LV Cable Systems for electrical connection, isolation and flexibility with network reconfiguration. Depending on the complexity of the LV Box, they may also offer monitoring and protection (fuse or circuit breaker) capabilities.	Failing to open on a fault (if used in this mode. Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions). Opens Spuriously under normal conditions. Opens Intermittently (Faulty).	Disruptive Failure Resulting from Insulation Breakdown.	Failure to be operable when required due to: - damage to contacts - moisture ingress - deteriorated links.	Failure to be operable when required due to: - damage to contacts - loose internal connections.	Failure of housing. Contact Damage due to Incorrect operation of Box.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
HV Switchgear (GM) – Primary / HV Switchgear (GM) - Distribution	Carry, make or break continuous load or fault current. Maintain or interrupt voltage on all three phases. Isolation & Earthing of Cables & Plant. Measurement of current and voltage.	Does not open or close on command (Where this is associated with the Breaker and not the control system). Mechanical Failure. Electrical Failure (Auxiliary & Control). Electrical Failure (Main Circuit).	Disruptive Failure Resulting from Insulation Breakdown.	SOP preventing operation. Failure to operate when required due to: - Failure of Mechanism - Protection module - CT Failure - VT Failure - Stuck Breaker.	Failure to operate when required due to: - Low Gas Lockout or Vacuum bottle condition.	Unable to withstand impulse voltage. Unable to contain the insulating medium. Does not allow switch tank to breath. Unable to support its own weight. Does not provide a connection to the substation earth mat.
EHV Switchgear (GM)	Carry, make or break continuous load or fault current. Maintain or interrupt voltage on all three phases. Isolation & Earthing of Cables & Plant. Measurement of current and voltage.	Does not open or close on command (Where this is associated with the Breaker and not the control system). Mechanical Failure. Electrical Failure (Auxiliary & Control). Electrical Failure (Main Circuit).	Disruptive Failure Resulting from Insulation Breakdown.	SOP preventing operation. Failure to operate when required due to: - Failure of Mechanism - Protection module - CT Failure - VT Failure - Stuck Breaker.	Failure to operate when required due to: - Low Gas Lockout or Vacuum bottle condition.	Unable to withstand impulse voltage. Unable to contain the insulating medium. Does not allow switch tank to breath. Unable to support its own weight. Does not provide a connection to the substation earth mat. Failure of civil structures or associated disconnectors. Any asset classed by RIG definition as EHV Swgr Other.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
132kV CBs	Carry, make or break continuous load or fault current. Maintain or interrupt voltage on all three phases. Isolation & Earthing of Cables & Plant. Measurement of current and voltage.	Does not open or close on command (Where this is associated with the Breaker and not the control system). Mechanical Failure. Electrical Failure (Auxiliary & Control). Electrical Failure (Main Circuit).	Disruptive Failure Resulting from Insulation Breakdown.	SOP preventing operation. Failure to operate when required due to: - Failure of Mechanism - Protection module - CT Failure - VT Failure - Stuck Breaker.	Failure to operate when required due to: - Low Gas Lockout or Vacuum bottle condition.	Unable to withstand impulse voltage. Unable to contain the insulating medium. Does not allow switch tank to breath. Unable to support its own weight. Does not provide a connection to the substation earth mat. Failure of civil structures or associated disconnectors. Any asset classed by RIG definition as EHV Swgr Other.
HV Transformer (GM)	Step up or step down and provide a secondary output voltage which is within statutory limits. Carry full load current when required. Carry through fault current when required.	Tapchanger, bushing, windings, core, tank or insulation failure.	Failure of the main internal components - windings, core or insulation.	Failure of the bushing, cable termination, including box and conservator tank.	Failure of the Tapchanger.	Oil condition corrected by an oil change and not re-conditioning, levels and leaks. Cable connection to controlling switchgear. Civil structure related failures.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
EHV Transformer / 132kV Transformer	Step up or step down and provide a secondary output voltage which is within statutory limits. Carry full load current when required. Carry through fault current when required.	Tapchanger, bushing, windings, core, tank, insulation or control/monitoring failure.	Failure of the tank or main internal components - windings, core or insulation.	Failure of the bushing, cable termination conservator tank and associated radiator.	Failure of the Tapchanger.	Oil condition corrected by an oil change and not re-conditioning, levels and leaks. CT's, VT's and on tank unit auxiliary transformers associated with the unit NER's and NEX's Neutral displacement VT's. Cable and busbar connection to controlling switchgear. Civil structure related failures. Buchholz.
Poles	Support electrical equipment in compliance with the ESQCR and Construction Regulations.	Decayed Pole. Decayed Struts. Snapped Stays.	Any structure whose components have either failed (broken) or whose residual strength has decreased to a level where immediate replacement of all or part of the structure is required.	Any structure whose components have a residual strength such that replacement is required within the timescale defined by the Company.	Vermin Damage resulting in Factor of Safety reduction requiring an intervention.	Broken Conductor. Broken or damaged fittings. Damaged or non-functioning plant. Broken or damaged insulation. Missing or degraded safety signs and anti climbing fixtures. Leaning poles where statutory clearances are not impacted. Cable boxes and platforms, including sealing ends.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
Towers	Support electrical equipment in compliance with the ESQCR.	Corrosion or distortion of the structure, i.e. bent member, failing foundations.	Any structure whose components have either failed (broken) or whose residual strength has decreased to a level where immediate replacement of all or part of the structure is required.	Any component of the structure who's condition is such that it prevents normal operation of the Tower, or degrades the residual strength of the Tower, requiring an intervention with in a defined period.	Corrosion to minor Tower components and land movements degrading the potential of the Towers stability.	Broken Conductor. Broken or damaged fittings. Broken or damaged insulation. Missing or degraded safety signs and anti-climbing fixtures. Cable boxes and platforms, including sealing ends.
Fittings / OHL Conductor	Carry load and fault current without annealing or sagging below the ESQCR limit. Maintain continuity under normal and fault conditions. Provide phase-phase and phase-earth insulation.	Flashover. Insulation failure. Corroded Conductor. Corroded Jumper. Corroded Fitting.	Loss of structural integrity of any component associated with an overhead line supported on Steel Tower, excluding any associated Tower mounted plant, such that the residual strength of the component required immediate intervention.	Loss of structural integrity of any component associated with an overhead line supported on the Tower, excluding any associated Tower mounted plant, such that the residual strength of the component required intervention within a prescribed timescale.	Cracked insulator	Loss of protection. Loss of plant. Earthing. Any issues relating to the support, safety notices and anti-climbing guards. Conductor icing which does not result in permanent damage to the conductor. Cable boxes and platforms (including sealing ends).
Pressurised Cable	Carry load and fault current safely and reliably, without overheating or causing damage to the environment.	Oil or Gas leak / Top up. Cable Fault. Joint Failure.	Cable Fault. Joint Fault.	Accessory or joint failure causing loss of fluid.	Pressure gauges. Sheath deterioration.	Sheath damage and or repair. Third party damages.
Submarine Cables	Carry load and fault current safely and reliably, without overheating or causing damage to the environment.	Cable Fault. Joint Failure.	Cable Fault. Joint Fault.	N/A	N/A	Sheath damage and or repair. Third party damages.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
Non Pressurised Cable	Carry load and fault current safely and reliably, without overheating or causing damage to the environment.	Cable fault. Joint failure.	Cable Fault. Joint Fault.	N/A	N/A	Sheath damage and or repair. Third party damages.
Concrete Structures	Carries a piece of switchgear and is an integral part of the plant. This excludes plinths for plant which is designed with legs or other types of support for the operable parts of the plant and all power transformers	Loss of residual strength or loss of stability.	Failure of the structure resulting in the plant item becoming unstable, the plant tilts or in any other way cannot be operated as a result of the condition of the concrete.	Loss of section. Cracking and spilling of the concrete such that the residual strength is between 80 and 100% of current condition.	Loss of chemical structure and hence reduction in strength.	Plinths. Auxiliary structures not made of concrete. Busbar supports.

APPENDIX B

CALIBRATION - PROBABILITY OF FAILURE

B.1 Normal Expected Life

Table 20: Normal Expected Life

Asset Register Category	Sub-division	Normal Expected Life
LV Poles	Concrete	60
	Steel	50
	Wood	55
	Other (e.g. fibreglass)	80
LV Circuit Breaker		60
LV Pillar (ID)		60
LV Pillar (OD at Substation)		60
LV Pillar (OD not at a Substation)		60
LV Board (WM)		60
LV UGB		55
LV Board (X-type Network) (WM)		60
6.6/11kV Poles	Concrete	60
	Steel	50
	Wood	55
	Other (e.g. fibreglass)	80
20kV Poles	Concrete	60
	Steel	50
	Wood	55
	Other (e.g. fibreglass)	80
HV Sub Cable		60
6.6/11kV CB (GM) Primary		55*
6.6/11kV CB (GM) Secondary		55*
6.6/11kV Switch (GM)		55
6.6/11kV RMU		55
6.6/11kV X-type RMU		55
20kV CB (GM) Primary		55*
20kV CB (GM) Secondary		55*
20kV Switch (GM)		55
20kV RMU		55
6.6/11kV Transformer (GM)		60
20kV Transformer (GM)		60
33kV Pole	Concrete	60
	Steel	50
	Wood	55
	Other (e.g. fibreglass)	80
66kV Pole	Concrete	60
	Steel	50
	Wood	55
	Other (e.g. fibreglass)	80
33kV OHL (Tower Line) Conductor	ACSR - greased	55
	ACSR - non-greased	50
	AAAC	60
	Cad Cu	50
	Cu	70
	Other	50
33kV Tower	Steelwork	80

Asset Register Category	Sub-division	Normal Expected Life
	Foundation - Fully Encased Concrete	95
	Foundation - Earth Grillage	60
	Paint System - Galvanising	30
	Paint System - Paint	20
33kV Fittings		40
66kV OHL (Tower Line) Conductor	ACSR - greased	55
	ACSR - non-greased	50
	AAAC	60
	Cad Cu	50
	Cu	70
	Other	50
66kV Tower	Steelwork	80
	Foundation - Fully Encased Concrete	95
	Foundation - Earth Grillage	60
	Paint System - Galvanising	30
	Paint System - Paint	20
66kV Fittings		40
33kV UG Cable (Non Pressurised)	Aluminium sheath - Aluminium conductor	100
	Aluminium sheath - Copper conductor	100
	Lead sheath - Aluminium conductor	100
	Lead sheath - Copper conductor	100
33kV UG Cable (Oil)	Aluminium sheath - Aluminium conductor	75
	Aluminium sheath - Copper conductor	75
	Lead sheath - Aluminium conductor	80
	Lead sheath - Copper conductor	80
33kV UG Cable (Gas)	Aluminium sheath - Aluminium conductor	65
	Aluminium sheath - Copper conductor	70
	Lead sheath - Aluminium conductor	75
	Lead sheath - Copper conductor	75
66kV UG Cable (Non Pressurised)	Aluminium sheath - Aluminium conductor	100
	Aluminium sheath - Copper conductor	100
	Lead sheath - Aluminium conductor	100
	Lead sheath - Copper conductor	100
66kV UG Cable (Oil)	Aluminium sheath - Aluminium conductor	75
	Aluminium sheath - Copper conductor	75
	Lead sheath - Aluminium conductor	80
	Lead sheath - Copper conductor	80
66kV UG Cable (Gas)	Aluminium sheath - Aluminium conductor	65
	Aluminium sheath - Copper conductor	70
	Lead sheath - Aluminium conductor	75
	Lead sheath - Copper conductor	75
EHV Sub Cable		60
33kV CB (Air Insulated Busbars)(ID) (GM)		60*
33kV CB (Air Insulated Busbars)(OD) (GM)		50*
33kV CB (Gas Insulated Busbars)(ID)(GM)		60*

Asset Register Category	Sub-division	Normal Expected Life
33kV CB (Gas Insulated Busbars)(OD)(GM)		50
33kV Switch (GM)		55
33kV RMU		55
66kV CB (Air Insulated Busbars)(ID) (GM)		50
66kV CB (Air Insulated Busbars)(OD) (GM)		55
66kV CB (Gas Insulated Busbars)(ID)(GM)		55
66kV CB (Gas Insulated Busbars)(OD)(GM)		50
33kV Transformer (GM)	Transformer - Pre 1980	60
	Transformer - Post 1980	50
	Tapchanger	60
66kV Transformer (GM)	Transformer - Pre 1980	60
	Transformer - Post 1980	50
	Tapchanger	60
132kV OHL (Tower Line) Conductor	ACSR - greased	55
	ACSR - non-greased	50
	AAAC	60
	Cad Cu	50
	Cu	70
	Other	50
132kV Tower	Steelwork	80
	Foundation - Fully Encased Concrete	95
	Foundation - Earth Grillage	60
	Paint System - Galvanising	30
	Paint System - Paint	20
132kV Fittings		40
132kV UG Cable (Non Pressurised)	Aluminium sheath - Aluminium conductor	100
	Aluminium sheath - Copper conductor	100
	Lead sheath - Aluminium conductor	100
	Lead sheath - Copper conductor	100
132kV UG Cable (Oil)	Aluminium sheath - Aluminium conductor	75
	Aluminium sheath - Copper conductor	75
	Lead sheath - Aluminium conductor	80
	Lead sheath - Copper conductor	80
132kV UG Cable (Gas)	Aluminium sheath - Aluminium conductor	65
	Aluminium sheath - Copper conductor	70
	Lead sheath - Aluminium conductor	75
	Lead sheath - Copper conductor	75
132kV Sub Cable		60
132kV CB (Air Insulated Busbars)(ID) (GM)		60
132kV CB (Air Insulated Busbars)(OD) (GM)		50
132kV CB (Gas Insulated Busbars)(ID) (GM)		60
132kV CB (Gas Insulated Busbars)(OD) (GM)		55
132kV Transformer (GM)	Transformer - Pre 1980	60
	Transformer - Post 1980	50
	Tapchanger	60

* The Normal Expected Life will be increased where applicable in accordance with Table 210 for assets that have been refurbished as specified in Appendix C.

B.2 PoF Curve Parameters

TABLE 21: POF CURVE PARAMETERS

Functional Failure Category	K-Value	C-Value	Health Score Limit
LV UGB	0.0077%	1.087	4
LV Circuit Breaker	0.0041%	1.087	4
LV Pillar (ID)	0.0046%	1.087	4
LV Pillar (OD at Substation) / LV Pillar (OD not at a Substation)			
LV Board (WM)	0.0069%	1.087	4
HV Switchgear (GM) - Primary	0.0052%	1.087	4
HV Switchgear (GM) - Distribution (GM)	0.0067%	1.087	4
EHV Switchgear (GM) (33kV & 22kV assets only)	0.0223%	1.087	4
EHV Switchgear (GM) (66kV assets only)	0.0512%	1.087	4
132kV CBs	0.0431%	1.087	4
HV Transformer (GM)	0.0078%	1.087	4
EHV Transformer/ 132kV Transformer	0.0454%	1.087	4
Poles	0.0285%	1.087	4
Towers	0.0879%	1.087	4
Fittings	0.0096%	1.087	4
OHL Conductor	0.0080%	1.087	4
Pressurised Cable (EHV UG Cable (Oil) and 132kV UG Cable (Oil))	3.7754%	1.087	4
Pressurised Cable (EHV UG Cable (Gas) and 132kV UG Cable (Gas))	4.5036%	1.087	4
Submarine Cables	0.0202%	1.087	4
Non Pressurised Cable	0.0658%	1.087	4

B.3 Location Factor

B.3.1 General

TABLE 22: DISTANCE FROM COAST FACTOR LOOKUP TABLE

Distance from Coast Banding	Switchgear	Transformers	Poles (Wood)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
≤ 1km	1.35	1.35	1	1.5	1.25	1.8	2	2
> 1km and ≤ 5km	1.1	1.1	1	1.2	1.1	1.45	1.5	1.5
> 5km and ≤ 10km	1.05	1.05	1	1.1	1.05	1.2	1.2	1.2
> 10km and ≤ 20km	1	1	1	1	1	1	1	1
>20km	0.9	0.9	1	1	1	0.85	1	1
Default	1	1	1	1	1	1	1	1

TABLE 23: ALTITUDE FACTOR LOOKUP TABLE

Altitude From Sea Level Banding	Switchgear	Transformers	Poles (Wood)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
≤ 100m	0.9	0.9	1	1	1	0.9	0.95	0.95
> 100m and ≤ 200m	1	1	1	1	1	1	1	1
> 200m and ≤ 300m	1.05	1.05	1	1	1	1.15	1.05	1.05
> 300m	1.1	1.1	1	1	1	1.3	1.15	1.15
Default	1	1	1	1	1	1	1	1

TABLE 24: CORROSION CATEGORY FACTOR LOOKUP TABLE

Corrosion Category Index	Switchgear	Transformers	Poles (Wood)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
1	0.9	0.9	1	0.9	0.9	0.75	0.95	0.95
2	0.95	0.95	1	0.95	0.95	0.9	0.95	0.95
3	1	1	1	1	1	1	1	1
4	1.1	1.1	1	1.15	1.05	1.3	1.05	1.05
5	1.25	1.25	1	1.35	1.1	1.6	1.2	1.2
Default	1	1	1	1	1	1	1	1

TABLE 25: INCREMENT CONSTANTS

Increment Constant	Switchgear	Transformers	Submarine Cables	Poles (Wood)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
INC	0.05	0.05	0.05	0	0	0	0	0	0

TABLE 25A: DEFAULT ENVIRONMENT (INDOOR/OUTDOOR)

Asset Register Category	Default 'environment' to be assumed when deriving Location Factor
LV Poles	Outdoor
LV Circuit Breaker	Indoor
LV Pillar (ID)	Indoor
LV Pillar (OD at Substation)	Outdoor
LV Pillar (OD not at a Substation)	Outdoor
LV Board (WM)	Indoor
LV UGB	n/a
LV Board (X-type Network) (WM)	Indoor
6.6/11kV Poles	Outdoor
20kV Poles	Outdoor
HV Sub Cable	n/a
6.6/11kV CB (GM) Primary	Indoor
6.6/11kV CB (GM) Secondary	Indoor
6.6/11kV Switch (GM)	Indoor
6.6/11kV RMU	Indoor
6.6/11kV X-type RMU	Indoor
20kV CB (GM) Primary	Indoor
20kV CB (GM) Secondary	Indoor
20kV Switch (GM)	Indoor
20kV RMU	Indoor
6.6/11kV Transformer (GM)	Indoor
20kV Transformer (GM)	Indoor
33kV Pole	Outdoor
66kV Pole	Outdoor
33kV OHL (Tower Line) Conductor	Outdoor
33kV Tower	Outdoor
33kV Fittings	Outdoor
66kV OHL (Tower Line) Conductor	Outdoor
66kV Tower	Outdoor

66kV Fittings	Outdoor
33kV UG Cable (Non Pressurised)	n/a
33kV UG Cable (Oil)	n/a
33kV UG Cable (Gas)	n/a
66kV UG Cable (Non Pressurised)	n/a
66kV UG Cable (Oil)	n/a
66kV UG Cable (Gas)	n/a
EHV Sub Cable	n/a
33kV CB (Air Insulated Busbars)(ID) (GM)	Indoor
33kV CB (Air Insulated Busbars)(OD) (GM)	Outdoor
33kV CB (Gas Insulated Busbars)(ID)(GM)	Indoor
33kV CB (Gas Insulated Busbars)(OD)(GM)	Outdoor
33kV Switch (GM)	Indoor
33kV RMU	Indoor
66kV CB (Air Insulated Busbars)(ID) (GM)	Indoor
66kV CB (Air Insulated Busbars)(OD) (GM)	Outdoor
66kV CB (Gas Insulated Busbars)(ID)(GM)	Indoor
66kV CB (Gas Insulated Busbars)(OD)(GM)	Outdoor
33kV Transformer (GM)	Outdoor
66kV Transformer (GM)	Outdoor
132kV OHL (Tower Line) Conductor	Outdoor
132kV Tower	Outdoor
132kV Fittings	Outdoor
132kV UG Cable (Non Pressurised)	n/a
132kV UG Cable (Oil)	n/a
132kV UG Cable (Gas)	n/a
132kV Sub Cable	n/a
132kV CB (Air Insulated Busbars)(ID) (GM)	Indoor
132kV CB (Air Insulated Busbars)(OD) (GM)	Outdoor
132kV CB (Gas Insulated Busbars)(ID) (GM)	Indoor
132kV CB (Gas Insulated Busbars)(OD) (GM)	Outdoor
132kV Transformer (GM)	Outdoor

B.3.2 Submarine Cables

TABLE 26: SUBMARINE CABLE TOPOGRAPHY FACTOR

Topography	Score (Sea)	Score (Land locked)
Low Detrimental Topography	1.25	0.5
Medium Detrimental Topography	1.5	0.6
High Detrimental Topography	2.25	0.9
Very High Detrimental Topography	3	1.2
Default	1.25	0.5

TABLE 27: SUBMARINE CABLE SITUATION FACTOR

Situation	Score
Laid on bed	1
Covered	0.9
Buried	0.8
Default	1

TABLE 28: SUBMARINE CABLE WIND/WAVE FACTOR

Rating	Description	Score
1	Sheltered sea loch, Wind <200 W/m2	1
2	Wave <15kW/m, Wind 200-800 W/m2	1.2
3	Wave >15kW/m, Wind > 800 W/m2	1.4
	Default	1

TABLE 29: COMBINED WAVE & CURRENT ENERGY FACTOR

Intensity	Scoring (Sea)	Scoring (Landlocked)
Low	1.1	1
Moderate	1.25	1.15
High	1.5	1.4
Default	1.1	1

B.4 Duty Factor

TABLE 30: DUTY FACTOR LOOKUP TABLES - CABLES

Duty Factor 1 (DF1)

Maximum % Utilisation under normal operating conditions	Duty Factor (LV & HV)	Duty Factor (EHV & 132kV)
≤ 50%	0.8	1
> 50% and ≤ 70%	0.9	1.1
> 70% and ≤ 100%	1	1.3
> 100%	1.8	2
Default	1	1

Duty Factor 2 (DF2)

Operating Voltage / Design Voltage	Duty Factor
≤ 40%	0.7
> 40% and ≤ 55%	0.8
> 55% and ≤ 70%	0.9
> 70%	1
Default	1

TABLE 31: DUTY FACTOR LOOKUP TABLE - SWITCHGEAR

Number of operations	Duty Factor
Normal/Low	1
High (eg: Auto-reclosers)	1.2
Default	1

TABLE 32: DUTY FACTOR LOOKUP TABLE - DISTRIBUTION TRANSFORMERS

Max % Utilisation under normal operating conditions	Duty Factor
≤ 50%	0.9
> 50% and ≤ 70%	0.95
> 70% and ≤ 100%	1
>100%	1.4
Default	1

TABLE 33: DUTY FACTOR LOOKUP TABLES - GRID & PRIMARY TRANSFORMERS

Transformer

Max % Utilisation under normal operating conditions	Duty Factor
≤ 50%	1
> 50% and ≤ 70%	1.05
> 70% and ≤ 100%	1.1
>100%	1.4
Default	1

Tapchanger

Average Number of Daily Taps	Duty Factor
≤ 7	0.9
> 7 and ≤ 14	1
> 14 and ≤ 28	1.2
> 28	1.3
Default	1

The above transformer and Tapchanger duty factors will not be combined into a single factor, as separate Health Scores will be calculated for each element.

B.5 Observed Condition Factors

B.5.1 Overview

The following calibration tables shall be used to determine the value of each Observed Condition Input for individual assets.

The Observed Condition Inputs consist of three elements:-

i) A Condition Input Factor, which is used in the derivation of the Observed Condition Factor;
ii) a Condition Input Cap, which specifies a Health Score value that is used in the derivation of the Observed Condition Cap;
iii) a Condition Input Collar, which specifies a Health Score value that is used in the derivation of the Observed Condition Collar.

The use of Observed Condition Inputs to create the Observed Condition Modifier is described in Section 6.9.

DNOs shall map their own observed condition data to the criteria shown in these calibration tables, in order to determine the appropriate values for each of the Observed Condition Inputs. Where no data is available the default values for the Observed Condition Inputs shall be applied.

B.5.2 LV UGB

TABLE 34: OBSERVED CONDITION INPUT - LV UGB: STEEL COVER & PIT CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	e.g. Major corrosion	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 35: OBSERVED CONDITION INPUT - LV UGB: WATER / MOISTURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Dry	1	10	0.5
Present in Pit	Evidence of moisture observed in pit	1.1	10	0.5
Present in Bell Housing	Evidence of moisture observed in bell housing	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 36: OBSERVED CONDITION INPUT - LV UGB: BELL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Satisfactory	No observed deterioration	0.9	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	e.g. Major corrosion	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 37: OBSERVED CONDITION INPUT - LV UGB: INSULATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Minor Deterioration	Chips and advanced aging	1	10	0.5
Major Deterioration	Evidence of flashover or damage, or degradation of insulation material	1.3	10	8
Default	No data available	1	10	0.5

TABLE 38: OBSERVED CONDITION INPUT - LV UGB: SIGNS OF HEATING

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Minor Deterioration	Observed running higher than ambient	1	10	0.5
Major Deterioration	Evidence of overheating	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 39: OBSERVED CONDITION INPUT - LV UGB: PHASE BARRIERS

Condition Criteria: Phase barriers Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Yes	Phase Barriers Present	1	10	0.5
Missing	Phase Barriers Not Present (in whole or part)	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.3 LV Circuit Breaker

TABLE 40: OBSERVED CONDITION INPUT - LV CIRCUIT BREAKER: EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.3	10	0.5
Substantial Deterioration	e.g. Major corrosion	1.6	10	0.5
Default	No data available	1	10	0.5

B.5.4 LV Board (WM)

TABLE 41: OBSERVED CONDITION INPUT - LV BOARD (WM): SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	e.g. Major corrosion	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 42: OBSERVED CONDITION INPUT - LV BOARD (WM): COMPOUND LEAKS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Good	No leakage	0.9	10	0.5
Slight leak	Evidence of slight compound leak	1	10	0.5
Poor	Significant compound leak	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 43: OBSERVED CONDITION INPUT - LV BOARD (WM): SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	Degradation of insulation material	1.4	10	8
Default	No data available	1	10	0.5

B.5.5 LV Pillars

TABLE 44: OBSERVED CONDITION INPUT - LV PILLARS: SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	Visible holes in casing or structurally unsound	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 45: OBSERVED CONDITION INPUT - LV PILLARS: COMPOUND LEAKS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Good	No leakage	0.9	10	0.5
Slight leak	Evidence of slight compound leak	1	10	0.5
Poor	Significant compound leak	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 46: OBSERVED CONDITION INPUT - LV PILLARS: SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	Degradation of insulation material	1.4	10	8
Default	No data available	1	10	0.5

TABLE 47: OBSERVED CONDITION INPUT - LV PILLARS: INSULATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Satisfactory	No observed deterioration	0.9	10	0.5
Some Deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Substantial Deterioration	Degradation of insulation material	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 48: OBSERVED CONDITION INPUT - LV PILLARS: SIGNS OF HEATING

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No obvious degradation	1	10	0.5
Minor Deterioration	Observed running higher than ambient	1.2	10	0.5
Major Deterioration	Evidence of overheating	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 49: OBSERVED CONDITION INPUT - LV PILLARS: PHASE BARRIERS

Condition Criteria: Phase barriers Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Yes	Phase Barriers Present	1	10	0.5
Missing	Phase Barriers Not Present (in whole or part)	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.6 HV Switchgear (GM) - Primary

TABLE 50: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	Severe corrosion (e.g. holes)	1.4	10	8
Default	No data available	1	10	0.5

TABLE 51: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar

Good	Oil: No leakage Gas: Pressure within acceptable range	0.9	10	0.5
Slight leak	Oil: Slight weep Gas: Not used	1	10	0.5
Poor	Oil: Free oil observed Gas: Pressure outside of acceptable range	1.1	10	0.5
Severe leak	Severe unrepairable leak and/or repeated gas top-ups	1.3	10	8
Default	No data available	1	10	0.5

TABLE 52: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above ambient	Above ambient temperature	1	10	0.5
Substantially above ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 53: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc	1.4	10	8
Default	No data available	1	10	0.5

TABLE 54: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	No heating or dehumidification installed; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

B.5.7 HV Switchgear (GM) - Distribution

TABLE 55: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	Severe corrosion (e.g. holes)	1.4	10	8
Default	No data available	1	10	0.5

TABLE 56: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Good	Oil: No leakage Gas: Pressure within acceptable range	0.9	10	0.5
Slight leak	Oil: Slight weep Gas: Not used	1	10	0.5
Poor	Oil: Free oil observed Gas: Pressure outside of acceptable range	1.1	10	0.5
Severe leak	Severe unrepairable leak and/or repeated gas top-ups	1.3	10	8
Default	No data available	1	10	0.5

TABLE 57: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 58: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc.	1.4	10	8
Default	No data available	1	10	0.5

TABLE 59: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than Expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	No heating or dehumidification installed; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

B.5.8 EHV Switchgear (GM)

TABLE 60: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	Severe corrosion (e.g. holes)	1.4	10	8
Default	No data available	1	10	0.5

TABLE 61: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Good	Oil: No leakage Gas: Pressure within acceptable range	0.9	10	0.5
Slight Leak	Oil: Slight weep Gas: Not used	1	10	0.5
Poor	Oil: Free oil observed Gas: Pressure outside of acceptable range	1.1	10	0.5
Severe Leak	Severe unrepairable leak and/or repeated gas top-ups	1.3	10	8
Default	No data available	1	10	0.5

TABLE 62: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 63: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar

As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc.	1.4	10	8
Default	No data available	1	10	0.5

TABLE 64: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than Expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	No heating or dehumidification installed; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

TABLE 65: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): SUPPORT STRUCTURES

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration		0.9	10	0.5
Normal Wear	Concrete Structures: Surface Deterioration Steel Structures: Minor localised surface corrosion	1	10	0.5
Some Deterioration	Concrete Structures: Minor cracks and loss of section Steel Structures: Some significant corrosion, minor loss of cross section	1.3	10	0.5
Substantial Deterioration	Concrete Structures: Loss of section, reinforcing exposed Steel Structures: Major corrosion, wasting of steel cross section, laminated rusk, holes or loss of steel at edges, severe damage	1.5	10	5.5
Default	No data available	1	10	0.5

B.5.9 132kV Switchgear (GM)

TABLE 66: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	Severe corrosion (e.g. holes)	1.4	10	8
Default	No data available	1	10	0.5

TABLE 67: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Good	Oil: No leakage Gas: Pressure within acceptable range	0.9	10	0.5
Slight leak	Oil: Slight weep Gas: Not used	1	10	0.5
Poor	Oil: Free oil observed Gas: Pressure outside of acceptable range	1.1	10	0.5
Severe leak	Severe unrepairable leak and/or repeated gas top-ups	1.3	10	8
Default	No data available	1	10	0.5

TABLE 68: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 69: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc.	1.4	10	8
Default	No data available	1	10	0.5

TABLE 70: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than Expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	No heating or dehumidification installed; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

TABLE 71: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): SUPPORT STRUCTURES

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration		0.9	10	0.5
Normal Wear	Concrete Structures: Surface Deterioration Steel Structures: Minor localised surface corrosion	1	10	0.5
Some Deterioration	Concrete Structures: Minor cracks and loss of section Steel Structures: Some significant corrosion, minor loss of cross section	1.3	10	0.5
Substantial Deterioration	Concrete Structures: Loss of section, reinforcing exposed Steel Structures: Major corrosion, wasting of steel cross section, laminated rusk, holes or loss of steel at edges, severe damage	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 72: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): AIR SYSTEMS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Minor Deterioration	Minor surface corrosion observed on observable pipe work	1	10	0.5
Minor Air Losses	System runs excessively to maintain pressure	1.3	10	0.5
Major Air Losses	Loss of pressure pipe section observed. Air leaks can be found by inspection; Certification Certificate notes defects. Etc.	1.5	10	0.5
Default	No data available	1	10	0.5

B.5.10 HV Transformer (GM)

TABLE 73: OBSERVED CONDITION INPUT - HV TRANSFORMER (GM): TRANSFORMER EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	Condition as new	0.9	10	0.5
Good	e.g. no evidence of corrosion or oil leakage	1	10	0.5
Slight Deterioration	e.g. minor localised surface corrosion, no evidence of oil leakage or slight (but repairable) oil leakage	1.1	10	0.5
Poor	e.g. some significant corrosion, or evidence of slight oil (unrepairable) leakage	1.25	10	0.5
Very Poor	e.g. major corrosion or evidence of significant oil leakage	1.4	10	8
Default	No data available	1	10	0.5

B.5.11 EHV Transformer (GM) (Main Transformer component)

TABLE 74: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): MAIN TANK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.4	10	0.5
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.8	10	8
Default	No data available	1	10	0.5

TABLE 75: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): COOLERS / RADIATOR CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 76: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): BUSHINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. visible cracks, damage, surface degradation and/or leakage	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 77: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): KIOSK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component exhibits some deterioration but is fit for continued service. There is no or little obvious signs of corrosion	1	10	0.5
Some Deterioration	e.g. minor corrosion	1.1	10	0.5
Substantial Deterioration	e.g. major corrosion	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 78: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of compound leaks (where appropriate)	1.1	10	0.5
Substantial Deterioration	e.g major corrosion	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.12 EHV Transformer (GM) (Tapchanger component)

TABLE 79: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): TAPCHANGER EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.4	10	0.5
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.8	10	8
Default	No data available	1	10	0.5

TABLE 80: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): INTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc.	1.4	10	8
Default	No data available	1	10	0.5

TABLE 81: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): DRIVE MECHANISM CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear to components	1.2	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 82: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER CONTACTS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.95	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.1	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 83: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER BRAIDS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.95	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.05	10	0.5
Substantial Deterioration	e.g. major corrosion or fraying of braids	1.1	10	0.5
Default	No data available	1	10	0.5

B.5.13 132kV Transformer (GM) (Main Transformer component)

TABLE 84: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): MAIN TANK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.4	10	0.5
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.8	10	8
Default	No data available	1	10	0.5

TABLE 85: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): COOLERS / RADIATOR CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 86: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): BUSHINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar

Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. visible cracks, damage, surface degradation and/or leakage	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 87: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): KIOSK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.1	10	0.5
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 88: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion or evidence of compound leaks (where appropriate)	1.1	10	0.5
Substantial Deterioration	e.g. Major corrosion or evidence of low level oil leaks (If appropriate)	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.14 132kV Transformer (GM) (Tapchanger component)

TABLE 89: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): TAPCHANGER EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.4	10	0.5
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.8	10	8
Default	No data available	1	10	0.5

TABLE 90: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): INTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	0.5
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc+	1.4	10	8
Default	No data available	1	10	0.5

TABLE 91: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): DRIVE MECHANISM CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for	1	10	0.5

	continued service. There is little deterioration			
Some Deterioration	e.g. minor corrosion or wear to components	1.2	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 92: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER CONTACTS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.95	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.1	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 93: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER BRAIDS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.95	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.05	10	0.5
Substantial Deterioration	e.g. major corrosion or fraying of braids	1.1	10	0.5
Default	No data available	1	10	0.5

B.5.15 Submarine Cable

TABLE 94: OBSERVED CONDITION INPUT - SUBMARINE CABLE: EXTERNAL CONDITION ARMOUR

Condition Criteria	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Good	The asset component exhibits deterioration but is fit for continued service.	1	10	0.5
Poor	e.g. visible damage to armour	1.6	10	5.5
Critical	e.g. mechanical damage to cable armour, loss of armour	1.8	10	8
Default	No data available	1	10	0.5

B.5.16 LV Poles

TABLE 95: OBSERVED CONDITION INPUT - LV POLE: VISUAL POLE CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	No defects observed	1	10	0.5
Some Deterioration	e.g. minor physical damage that will lead to loss of strength	1.3	10	0.5
Substantial Deterioration	e.g. visible splits, cracks, major physical damage affecting strength	1.8	10	8
Default	No data available	1	10	0.5

TABLE 96: OBSERVED CONDITION INPUT - LV POLE: POLE TOP ROT

Condition Criteria: Pole Top Rot Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	No pole top rot observed	1	10	0.5
Yes	Pole top rot is observed	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 97: OBSERVED CONDITION INPUT - LV POLE: POLE LEANING

Condition Criteria: Pole Leaning?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	The pole is vertical	1	10	0.5
Yes	The pole is not vertical	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 98: OBSERVED CONDITION INPUT - LV POLE: BIRD / ANIMAL DAMAGE

Condition Criteria: Bird/ Animal Damage?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	There is no animal damage	1	10	0.5
Yes	There is animal damage	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.17 HV Poles

TABLE 99: OBSERVED CONDITION INPUT - HV POLE: VISUAL POLE CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	No defects observed	1	10	0.5
Some Deterioration	e.g. minor physical damage that will lead to loss of strength	1.3	10	0.5
Substantial Deterioration	e.g. visible splits, cracks, major physical damage affecting strength	1.8	10	8
Default	No data available	1	10	0.5

TABLE 100: OBSERVED CONDITION INPUT - HV POLE: VISUAL POLE CONDITION: POLE TOP ROT

Condition Criteria: Pole Top Rot Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	No pole top rot observed	1	10	0.5
Yes	Pole top rot is observed	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 101: OBSERVED CONDITION INPUT - HV POLE: POLE LEANING

Condition Criteria: Pole Leaning?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	The pole is vertical	1	10	0.5

Yes	The pole is not vertical	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 102: OBSERVED CONDITION INPUT - HV POLE: BIRD / ANIMAL DAMAGE

Condition Criteria: Bird/ Animal Damage?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	There is no animal damage	1	10	0.5
Yes	There is animal damage	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.18 EHV Poles

TABLE 103: OBSERVED CONDITION INPUT - EHV POLE: VISUAL POLE CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	No defects observed	1	10	0.5
Some Deterioration	e.g. minor physical damage that will lead to loss of strength	1.3	10	0.5
Substantial Deterioration	e.g. visible splits, cracks, major physical damage affecting strength	1.8	10	8
Default	No data available	1	10	0.5

TABLE 104: OBSERVED CONDITION INPUT - EHV POLE: POLE TOP ROT

Condition Criteria: Pole Top Rot Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	No pole top rot observed	1	10	0.5
Yes	Pole top rot is observed	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 105: OBSERVED CONDITION INPUT - EHV POLE: POLE LEANING

Condition Criteria: Pole Leaning?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	The pole is vertical	1	10	0.5
Yes	The pole is not vertical	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 106: OBSERVED CONDITION INPUT - EHV POLE: BIRD / ANIMAL DAMAGE

Condition Criteria: Bird/ Animal Damage?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	There is no animal damage	1	10	0.5
Yes	There is animal damage	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.19 EHV Towers (Tower Steelwork component)

TABLE 107: OBSERVED CONDITION INPUT - EHV TOWER: TOWER LEGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 108: OBSERVED CONDITION INPUT - EHV TOWER: BRACINGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 109: OBSERVED CONDITION INPUT - EHV TOWER: CROSSARMS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 110: OBSERVED CONDITION INPUT - EHV TOWER: PEAK

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	0.5
Default	No data available	1	10	0.5

B.5.20 EHV Towers (Tower Paintwork component)

TABLE 111: OBSERVED CONDITION INPUT - EHV TOWER: PAINTWORK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New		1	6.4	0.5
Slight Rust Breakthrough	Slight rust breakthrough - up to 5% of surface area affected.	1.1	6.4	0.5
Moderate Rust Breakthrough	Moderate rust breakthrough - between 5% and 20% of surface area affected, and/or pitted rust	1.6	6.4	0.5
Severe Rust Breakthrough	Severe rust breakthrough - more than 20% of surface area affected, AND/OR damaged or bent steelwork, AND/OR any blistered paintwork with evidence of severe rust underneath, painting/attention required urgently.	1.8	6.4	5.5
Default	No data available	1	6.4	0.5

B.5.21 EHV Towers (Tower Foundation component)

TABLE 112: OBSERVED CONDITION INPUT - EHV TOWER: FOUNDATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.95	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion	1.4	10	0.5
Substantial Deterioration	Insufficient integrity to support tower loading	1.8	10	8
Default	No data available	1	10	0.5

B.5.22 132kV Towers (Tower Steelwork component)

TABLE 113: OBSERVED CONDITION INPUT - 132KV TOWER: TOWER LEGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 114: OBSERVED CONDITION INPUT - 132KV TOWER: BRACINGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 115: OBSERVED CONDITION INPUT - 132KV TOWER: CROSSARMS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 116: OBSERVED CONDITION INPUT - 132KV TOWER: PEAK

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	10	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	0.5
Default	No data available	1	10	0.5

B.5.23 132kV Towers (Tower Paintwork component)

TABLE 117: OBSERVED CONDITION INPUT - 132KV TOWER: PAINTWORK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New		1	6.4	0.5
Slight Rust Breakthrough	Slight rust breakthrough - up to 5% of surface area affected.	1.1	6.4	0.5
Moderate Rust Breakthrough	Moderate rust breakthrough - between 5% and 20% of surface area affected, and/or pitted rust	1.6	6.4	0.5
Severe Rust Breakthrough	Severe rust breakthrough - more than 20% of surface area affected, AND/OR damaged or bent steelwork, AND/OR any blistered paintwork with evidence of severe rust underneath, painting/attention required urgently.	1.8	6.4	5.5
Default	No data available	1	6.4	0.5

B.5.24 132kV Towers (Tower Foundation component)

TABLE 118: OBSERVED CONDITION INPUT - 132KV TOWER: FOUNDATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.95	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion	1.4	10	0.5
Substantial Deterioration	Insufficient integrity to support tower loading	1.8	10	8
Default	No data available	1	10	0.5

B.5.25 EHV Fittings

TABLE 119: OBSERVED CONDITION INPUT - EHV FITTINGS: TOWER FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required structural integrity	1.3	10	0.5
Substantial Deterioration	Loss of required structural integrity	1.4	10	8
Default	No data available	1	10	0.5

TABLE 120: OBSERVED CONDITION INPUT - EHV FITTINGS: CONDUCTOR FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	0.5
Substantial Deterioration	Loss of required structural integrity	1.4	10	8
Default	No data available	1	10	0.5

TABLE 121: OBSERVED CONDITION INPUT - EHV FITTINGS: INSULATORS - ELECTRICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required electrical Integrity	1.3	10	0.5
Substantial Deterioration	Loss of required electrical integrity	1.4	10	8
Default	No data available	1	10	0.5

TABLE 122: OBSERVED CONDITION INPUT - EHV FITTINGS: INSULATORS - MECHANICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required structural integrity	1.3	10	0.5
Substantial Deterioration	Loss of required structural integrity	1.4	10	8
Default	No data available	1	10	0.5

B.5.26 132kV Fittings

TABLE 123: OBSERVED CONDITION INPUT - 132KV FITTINGS: TOWER FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	0.5
Substantial Deterioration	Loss of required structural integrity	1.4	10	8
Default	No data available	1	10	0.5

TABLE 124: OBSERVED CONDITION INPUT - 132KV FITTINGS: CONDUCTOR FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	0.5
Substantial Deterioration	Loss of required structural integrity	1.4	10	8
Default	No data available	1	10	0.5

TABLE 125: OBSERVED CONDITION INPUT - 132KV FITTINGS: INSULATORS - ELECTRICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required electrical integrity	1.3	10	0.5
Substantial Deterioration	Loss of required electrical integrity	1.4	10	8
Default	No data available	1	10	0.5

TABLE 126: OBSERVED CONDITION INPUT - 132KV FITTINGS: INSULATORS - MECHANICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	0.5
Substantial Deterioration	Loss of required structural integrity	1.4	10	8
Default	No data available	1	10	0.5

B.5.27 EHV Tower Line Conductor

TABLE 127: OBSERVED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: VISUAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	e.g. minor corrosion	1.3	10	0.5
Substantial Deterioration	e.g. birdcaging, broken strands, loss of section	1.4	10	8
Default	No data available	1	10	0.5

TABLE 128: OBSERVED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: MIDSPAN JOINTS

Condition Criteria: No. of Midspan Joints	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
0	No joints in the span. A span includes all conductors in that span	1	10	0.5
1	1 joint in the span	1.05	10	0.5
2	2 joints in the span	1.1	10	0.5
>2	More than two joints in the span	1.2	10	5.5
Default	No data available	1	10	0.5

B.5.28 132kV Tower Line Conductor

TABLE 129: OBSERVED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: VISUAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	No observed deterioration	0.9	10	0.5
Normal Wear	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	e.g. minor corrosion	1.3	10	0.5
Substantial Deterioration	e.g. birdcaging, broken strands, loss of section	1.4	10	8
Default	No data available	1	10	0.5

TABLE 130: OBSERVED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: MIDSPAN JOINTS

Condition Criteria: No. of Midspan Joints	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
0	No joints in the span. A span includes all conductors in that span	1	10	0.5
1	1 joint in the span	1.05	10	0.5
2	2 joints in the span	1.1	10	0.5
>2	More than two joints in the span	1.2	10	5.5
Default	No data available	1	10	0.5

B.6 Measured Condition Factors

B.6.1 Overview

The following calibration tables shall be used to determine the value of each Measured Condition Input for individual assets.

The Measured Condition Inputs consist of three elements:-

i) A Condition Input Factor, which is used in the derivation of the Measured Condition Factor;
ii) a Condition Input Cap, which specifies a Health Score value that is used in the derivation of the Measured Condition Cap;
iii) a Condition Input Collar, which specifies a Health Score value that is used in the derivation of the Measured Condition Collar.

The use of Measured Condition Inputs to create the Measured Condition Modifier is described in Section 6.10.

DNOs shall map their own observed condition data to the criteria shown in these calibration tables, in order to determine the appropriate values for each of the Measured Condition Inputs. Where no data is available the default values for the Measured Condition Inputs shall be applied.

B.6.2 LV UGB

TABLE 131: MEASURED CONDITION INPUT - LV UGB: OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Operable	The LV UGB can be operated safely	1	10	0.5
Inoperable	The LV UGB cannot be operated or repaired	1.5	10	8
Default	No data available	1	10	0.5

B.6.3 LV Circuit Breaker

TABLE 132: MEASURED CONDITION INPUT - LV CIRCUIT BREAKER: OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	The device can be operated safely	1	10	0.5
Unacceptable	The device cannot be operated safely	1.6	10	8
Default	No data available	1	10	0.5

B.6.4 LV Board (WM)

TABLE 133: MEASURED CONDITION INPUT - LV BOARD (WM): OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Operable	The LV Board can be operated safely	1	10	0.5
Inoperable - Secure	The LV Board cannot be operated but is physically secure	1.3	10	0.5
Inoperable - Hazardous	The LV Board cannot be operated and presents a hazard to either operator, the public or both	1.5	10	8
Default	No data available	1	10	0.5

TABLE 134: MEASURED CONDITION INPUT - LV BOARD (WM): SECURITY

Condition Criteria: Security	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Satisfactory	The device can be operated safely	1	10	0.5
Unsatisfactory	The device cannot be operated safely	1.3	10	0.5
Default	No data available	1	10	0.5

B.6.5 LV Pillars

TABLE 135: MEASURED CONDITION INPUT - LV PILLAR: OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Operable	The LV Pillar can be operated safely	1	10	0.5
Inoperable - Secure	The LV Pillar cannot be operated but is physically secure	1.3	10	0.5
Inoperable - Hazardous	The LV Pillar cannot be operated and presents a hazard to either operator, the public or both	1.5	10	8
Default	No data available	1	10	0.5

B.6.6 HV Switchgear (GM) - Primary

TABLE 136: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 137: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 138: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: IR TEST

Condition Criteria: IR Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The insulation test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 139: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: OIL TESTS

Condition Criteria: Oil Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil test result meets the required European Standard for new oil	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 140: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above ambient	Above ambient temperature	1	10	0.5
Substantially above ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 141: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.7 HV Switchgear (GM) - Distribution

TABLE 142: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 143: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the ‘As New’ condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the ‘As New’ condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 144: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: OIL TESTS

Condition Criteria: Oil Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil test result meets the required European Standard for new oil	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the ‘As New’ condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the ‘As New’ condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 145: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 146: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.8 EHV Switchgear (GM)

TABLE 147: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 148: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 149: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): IR TEST

Condition Criteria: IR Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The insulation test result meets the manufacturers recommended value	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 150: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): OIL TESTS / GAS TESTS

Condition Criteria: Oil Test/ Gas Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil or gas test result meets the required European Standard for new oil or gas	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 151: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 152: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.9 132kV Switchgear (GM)

TABLE 153: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 154: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 155: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): IR TEST

Condition Criteria: IR Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The insulation test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 156: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): OIL TESTS / GAS TESTS

Condition Criteria: Oil Test/ Gas Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil or gas test result meets the required European Standard for new oil or gas	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 157: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 158: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.10 HV Transformer (GM)

TABLE 159: MEASURED CONDITION INPUT - HV TRANSFORMER (GM): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 160: MEASURED CONDITION INPUT - HV TRANSFORMER (GM): OIL ACIDITY

Condition Criteria: Oil Acidity (mg KOH/g)	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
≤ 0.15	The measure acidity of the oil is in the range indicated	0.9	10	0.5
> 0.15 and ≤ 0.3		1	10	0.5
> 0.3 and ≤ 0.5		1.15	10	0.5
> 0.5		1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 161: MEASURED CONDITION INPUT - HV TRANSFORMER (GM): TEMPERATURE READINGS

Condition Criteria:	Description	Condition Input	Condition	Condition

Temperature Reading		Factor	Input Cap	Input Collar
Normal	Normally expected temperature for transformer loading	1	10	0.5
Moderately High	Slightly above normally expected temperature for transformer loading	1.2	10	0.5
Very High	Significantly above normally expected temperature for transformer loading	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.11 EHV Transformer (GM) (Main Transformer Component)

TABLE 162: MEASURED CONDITION INPUT - EHV TRANSFORMER (GM): MAIN TRANSFORMER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial Discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 163: MEASURED CONDITION INPUT - EHV TRANSFORMER (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Reading	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal	Normally expected temperature for transformer loading	1	10	0.5
Moderately High	Slightly above normally expected temperature for transformer loading	1.2	10	0.5
Very High	Significantly above normally expected temperature for transformer loading	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.12 EHV Transformer (GM) (Tapchanger component)

TABLE 164: MEASURED CONDITION INPUT - EHV TRANSFORMER (GM): TAPCHANGER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

B.6.13 132kV Transformer (GM) (Main Transformer Component)

TABLE 165: MEASURED CONDITION INPUT - 132KV TRANSFORMER (GM): MAIN TRANSFORMER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 166: MEASURED CONDITION INPUT - 132KV TRANSFORMER (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Reading	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal	Normally expected temperature for transformer loading	1	10	0.5
Moderately High	Slightly above normally expected temperature for transformer loading	1.2	10	0.5
Very High	Significantly above normally expected temperature for transformer loading	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.14 132kV Transformer (GM) (Tapchanger component)

TABLE 167: MEASURED CONDITION INPUT - 132KV TRANSFORMER (GM): TAPCHANGER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High Partial Discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

B.6.15 EHV Cable (Non Pressurised)

TABLE 168: MEASURED CONDITION INPUT - EHV CABLE (NON PRESSURISED): SHEATH TEST

Condition Criteria: Sheath Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Satisfactory	1	10	0.5
Failed Minor	Failure requiring minor repair	1.3	10	0.5
Failed Major	Unacceptable sheath leakage or condition	1.6	10	5.5
Default	No data available	1	10	0.5

TABLE 169: MEASURED CONDITION INPUT - EHV CABLE (NON PRESSURISED): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No unusual activity detected	1	10	0.5
Medium	PD detected requiring regular monitoring	1.15	10	0.5
High	Intervention required	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 170: MEASURED CONDITION INPUT - EHV CABLE (NON PRESSURISED): FAULT HISTORY

Condition Criteria: Fault Rate (faults per annum)	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No historic faults recorded	No recorded faults or failures in the period	1	5.4	0.5
<0.01 per km	The calculated fault rate for the asset in the period	1.3	10	0.5
≥0.01 and <0.1 per km		1.6	10	5.5
≥0.1 per km		1.8	10	8
Default	No data available	1	10	0.5

B.6.16 EHV Cable (Oil)

TABLE 171: NOT REQUIRED

TABLE 172: MEASURED CONDITION INPUT - EHV CABLE (OIL): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of oil loss	2	10	8
Default	No data available	1	10	0.5

B.6.17 EHV Cable (Gas)

TABLE 173: NOT REQUIRED

TABLE 174: MEASURED CONDITION INPUT - EHV CABLE (GAS): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of gas loss	2	10	8
Default	No data available	1	10	0.5

B.6.18 132kV Cable (Non Pressurised)

TABLE 175: MEASURED CONDITION INPUT - 132KV CABLE (NON PRESSURISED): SHEATH TEST

Condition Criteria: Sheath Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Satisfactory	1	10	0.5
Failed Minor	Failure requiring minor repair	1.3	10	0.5
Failed Major	Unacceptable Sheath Leakage or Condition	1.6	10	5.5
Default	No data available	1	10	0.5

TABLE 176: MEASURED CONDITION INPUT - 132KV CABLE (NON PRESSURISED): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No unusual activity detected	1	10	0.5
Medium	PD detected requiring regular monitoring	1.15	10	0.5
High	Intervention required	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 177: MEASURED CONDITION INPUT - 132KV CABLE (NON PRESSURISED): FAULT HISTORY

Condition Criteria: Fault Rate (faults per annum)	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No historic faults recorded	No recorded faults or failures in the period	1	5.4	0.5
<0.01 per km	The calculated fault rate for the asset in the period	1.3	10	0.5
≥0.01 and <0.1 per km		1.6	10	5.5
≥0.1 per km		1.8	10	8
Default	No data available	1	10	0.5

B.6.19 132kV Cable (Oil)

TABLE 178: NOT REQUIRED

TABLE 179: MEASURED CONDITION INPUT - 132KV CABLE (OIL): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of oil loss	2	10	8
Default	No data available	1	10	0.5

B.6.20 132kV Cable (Gas)

TABLE 180: NOT REQUIRED

TABLE 181: MEASURED CONDITION INPUT - 132KV CABLE (GAS): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of gas loss	2	10	8
Default	No data available	1	10	0.5

B.6.21 Submarine Cable

TABLE 182: MEASURED CONDITION INPUT - SUBMARINE CABLE: SHEATH TEST

Condition Criteria: Sheath Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Satisfactory	1	10	0.5
Failed Minor	Failure requiring minor repair	1.3	10	0.5
Failed Major	Unacceptable sheath leakage or condition	1.6	10	5.5
Default	No data available	1	10	0.5

TABLE 183: MEASURED CONDITION INPUT - SUBMARINE CABLE: PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No unusual activity detected	1	10	0.5
Medium	PD detected requiring regular monitoring	1.15	10	0.5
High	Intervention required	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 184: MEASURED CONDITION INPUT - SUBMARINE CABLE: FAULT HISTORY

Condition Criteria: Fault Rate (faults per annum)	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No historic faults recorded	No recorded faults or failures in the period	1	5.4	0.5
<0.01 per km	The calculated fault rate for the asset in the period	1.3	10	0.5
≥0.01 and <0.1 per km		1.6	10	5.5
≥0.1 per km		1.8	10	8
Default	No data available	1	10	0.5

B.6.22 LV Poles

TABLE 185: MEASURED CONDITION INPUT - LV POLE: POLE DECAY / DETERIORATION

Condition Criteria: Degree of Decay/Deterioration	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Zero measured loss of strength	0.8	5.4	0.5
No Significant Decay/Deterioration	Minor loss of strength	1	6.4	0.5
High	Significant loss of residual strength, still within acceptable level	1.4	10	5.5
Very High	Residual strength below acceptable level	1.8	10	8
Default	No data available	1	10	0.5

B.6.23 HV Poles

TABLE 186: MEASURED CONDITION INPUT - HV POLE: POLE DECAY / DETERIORATION

Condition Criteria: Degree of Decay/Deterioration	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Zero measured loss of strength	0.8	5.4	0.5
No Significant Decay/Deterioration	Minor loss of strength	1	6.4	0.5
High	Significant loss of residual strength, still within acceptable level	1.4	10	5.5
Very High	Residual strength below acceptable level	1.8	10	8
Default	No data available	1	10	0.5

B.6.24 EHV Poles

TABLE 187: MEASURED CONDITION INPUT - EHV POLE: POLE DECAY / DETERIORATION

Condition Criteria: Degree of Decay/Deterioration	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Zero measured loss of strength	0.8	5.4	0.5
No Significant Decay/Deterioration	Minor loss of strength	1	6.4	0.5
High	Significant loss of residual strength, still within acceptable level	1.4	10	5.5
Very High	Residual strength below acceptable level	1.8	10	8
Default	No data available	1	10	0.5

B.6.25 EHV Fittings

TABLE 188: MEASURED CONDITION INPUT - EHV FITTINGS: THERMAL IMAGING

Condition Criteria: Thermal Imaging Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Ambient plus or minus 10^{0}C	1	5.4	0.5
Medium	Ambient plus 10 - 25^{0}C	1.1	10	0.5
High	Ambient plus more than 25^{0}C	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 189: MEASURED CONDITION INPUT - EHV FITTINGS: DUCTOR TEST

Condition Criteria: Ductor Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	As commissioned or up to 2.5% variance	1	5.4	0.5
Medium	As commissioned or up to 5% variance	1.1	10	0.5
High	As commissioned or over 5% variance	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.26 132kV Fittings

TABLE 190: MEASURED CONDITION INPUT - 132KV FITTINGS: THERMAL IMAGING

Condition Criteria: Thermal Imaging Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Ambient plus or minus 10^{0}C	1	5.4	0.5
Medium	Ambient plus 10 - 25^{0}C	1.1	10	0.5
High	Ambient plus more than 25^{0}C	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 191: MEASURED CONDITION INPUT - 132KV FITTINGS: DUCTOR TEST

Condition Criteria: Ductor Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	As commissioned or up to 2.5% variance	1	5.4	0.5
Medium	As commissioned or up to 5% variance	1.1	10	0.5
High	As commissioned or over 5% variance	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.27 EHV Tower Line Conductor

TABLE 192: MEASURED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: CONDUCTOR SAMPLING

Condition Criteria: Conductor Sampling Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	0.5
High	Wear indicated that an end of life condition exists	1.4	10	8
Default	No data available	1	10	0.5

TABLE 193: MEASURED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: CORROSION MONITORING SURVEY

Condition Criteria: Corrosion Monitoring Survey Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	0.5
High	Wear indicated that an end of life condition exists	1.4	10	8
Default	No data available	1	10	0.5

B.6.28 132kV Tower Line Conductor

TABLE 194: MEASURED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: CONDUCTOR SAMPLING

Condition Criteria: Conductor Sampling Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	0.5
High	Wear indicated that an end of life condition exists	1.4	10	8
Default	No data available	1	10	0.5

TABLE 195: MEASURED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: CORROSION MONITORING SURVEY

Condition Criteria: Corrosion Monitoring Survey Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	0.5
High	Wear indicated that an end of life condition exists	1.4	10	8
Default	No data available	1	10	0.5

B.7 Oil Test Modifier

TABLE 196: MOISTURE CONDITION STATE CALIBRATION

> Moisture (ppm)	<= Moisture (ppm)	Moisture Score
-0.01	15.00	0
15.00	25.00	2
25.00	35.00	4
35.00	45.00	8
45.00	10,000.00	10

TABLE 197: ACIDITY CONDITION STATE CALIBRATION

> Acidity (mg KOH/g)	<= Acidity (mg KOH/g)	Acidity Score
-0.01	0.10	0
0.10	0.15	2
0.15	0.20	4
0.20	0.30	8
0.30	10,000.00	10

TABLE 198: BREAKDOWN STRENGTH CONDITION STATE CALIBRATION

> BD Strength (kV)	<= BD Strength (kV)	BD Strength Score
-0.01	30.00	10
30.00	40.00	4
40.00	50.00	2
50.00	10,000.00	0

TABLE 199: OIL TEST FACTOR CALIBRATION

> Oil Condition Score	<= Oil Condition Score	Oil Test Factor
-0.01	50	0.90
50	200	1.00
200	500	1.05
500	1,000	1.10
1,000	10,000	1.20

TABLE 200: OIL TEST COLLAR CALIBRATION

> Oil Condition Score	<= Oil Condition Score	Oil Test Collar
-0.01	50	0.5
50	200	0.5
200	500	0.5
500	1,000	0.5
1,000	10,000	3.0

B.8 DGA Test Modifier

TABLE 201: HYDROGEN CONDITION STATE CALIBRATION

> Hydrogen (ppm)	<= Hydrogen (ppm)	Hydrogen Condition State
-0.01	20.00	0
20.00	40.00	2
40.00	100.00	4
100.00	200.00	10
200.00	10,000.00	16

TABLE 202: METHANE CONDITION STATE CALIBRATION

> Methane (ppm)	<= Methane (ppm)	Methane Condition State
-0.01	10.00	0
10.00	20.00	2
20.00	50.00	4
50.00	150.00	10
150.00	10,000.00	16

TABLE 203: ETHYLENE CONDITION STATE CALIBRATION

> Ethylene (ppm)	<= Ethylene (ppm)	Ethylene Condition State

-0.01	10.00	0
10.00	20.00	2
20.00	50.00	4
50.00	150.00	10
150.00	10,000.00	16

TABLE 204: ETHANE CONDITION STATE CALIBRATION

> Ethane (ppm)	<= Ethane (ppm)	Ethane Condition State
-0.01	10.00	0
10.00	20.00	2
20.00	50.00	4
50.00	150.00	10
150.00	10,000.00	16

TABLE 205: ACETYLENE CONDITION STATE CALIBRATION

> Acetylene (ppm)	<= Acetylene (ppm)	Acetylene Condition State
-0.01	1.00	0
1.00	5.00	2
5.00	20.00	4
20.00	100.00	8
100.00	10,000.00	10

TABLE 206: DGA CHANGE CATEGORY CALIBRATION

> % Change	<= % Change	Change Category
-1,000.00	-5.00	Negative
-5.00	5.00	Neutral
5.00	25.00	Small
25.00	100.00	Significant
100.00	1,000.00	Large

TABLE 207: DGA TEST FACTOR CALIBRATION

> % Change	DGA Test Factor
Negative	0.90
Neutral	1.00
Small	1.10
Significant	1.20
Large	1.50

B.9 FFA Test Modifier

TABLE 208: FFA TEST FACTOR

> FFA value (ppm)	<= FFA value (ppm)	FFA Test Factor
-0.01	4.00	1
4.00	5.00	1.1
5.00	6.00	1.25
6.00	7.00	1.4
7.00		1.6

B.10 Ageing Reduction Factor

TABLE 209: AGEING REDUCTION FACTOR

Current Health Score	Ageing Reduction Factor
< 2	1
2 to 5.5	((Current Health Score - 2)/ 7) + 1
> 5.5	1.5

APPENDIX C
INTERVENTIONS

Where work is carried out to either replace or refurbish an asset, that work will impact the value of the PoF and in some cases the CoF of the asset and hence a revised value of risk can be calculated for that asset. The change in the risk of the asset will be calculated by changes to the assets condition as observed or measured, being placed in the model and the model run to determine these changes. The change in risk will be calculated as the level of risk pre-intervention less the risk post-intervention.

Where a DNO needs to predict changes to the value of the overall risk present on their network due to their proposed work programme prior to that work being carried out, then the actual condition of the plant post intervention will not be able to be recorded. This is especially a problem where a refurbishment is proposed. In these cases the principles within this appendix will be used and suitable assumption will be permitted. These assumptions will be stated when submitting the results to Ofgem.

TABLE 210: INPUT DATA AFFECTED BY REFURBISHMENT INTERVENTIONS

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected By Intervention
Complete replacement of the operating mechanism (ACB)	LV Switchgear	LV Circuit Breaker	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of complete feederway	LV Switchgear	LV Pillar (ID), LV Pillar (OD at Substation) & LV Pillars (OD not at Substation)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete factory refurbishment	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete replacement of the operating mechanism	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of the moving portion (truck) in withdrawable equipment	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary & 20kV CB (GM) Secondary	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Increase the Expected Life by 20 years
Complete factory refurbishment	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected By Intervention
Complete replacement of the operating mechanism	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of the moving portion (truck) in withdrawable equipment	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Increase the Expected Life by 20 years
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID) (GM), 33kV CB (Air Insulated Busbars)(OD) (GM), 33kV CB (Gas Insulated Busbars)(ID) (GM), 33kV CB (Gas Insulated Busbars)(OD) (GM), 33kV RMU, 33kV Switch (GM), 66kV CB (Air Insulated Busbars)(ID) (GM), 66kV CB (Air Insulated Busbars)(OD) (GM), 66kV CB (Gas Insulated Busbars)(ID) (GM) & 66kV CB (Gas Insulated Busbars)(OD) (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete replacement of the operating mechanism	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID) (GM), 33kV CB (Air Insulated Busbars)(OD) (GM), 33kV CB (Gas Insulated Busbars)(ID) (GM), 33kV CB (Gas Insulated Busbars)(OD) (GM), 33kV RMU, 33kV Switch (GM), 66kV CB (Air Insulated Busbars)(ID) (GM), 66kV CB (Air Insulated Busbars)(OD) (GM), 66kV CB (Gas Insulated Busbars)(ID) (GM) & 66kV CB (Gas Insulated Busbars)(OD) (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID) (GM), 33kV CB (Air Insulated Busbars)(OD) (GM), 33kV CB (Gas Insulated Busbars)(ID) (GM), 33kV CB (Gas Insulated Busbars)(OD) (GM), 33kV RMU, 33kV Switch (GM), 66kV CB (Air Insulated Busbars)(ID) (GM), 66kV CB (Air Insulated Busbars)(OD) (GM), 66kV CB (Gas Insulated Busbars)(ID) (GM) & 66kV CB (Gas Insulated Busbars)(OD) (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of the moving portion (truck) in withdrawable equipment	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID) (GM), 33kV CB (Air Insulated Busbars)(OD) (GM) & 33kV CB (Gas Insulated Busbars)(ID) (GM)	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Increase the Expected Life by 20 years

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected By Intervention
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	132kV CBs	132kV CB (Air Insulated Busbars)(ID) (GM), 132kV CB (Air Insulated Busbars)(OD) (GM), 132kV CB (Gas Insulated Busbars)(ID) (GM) & 132kV CB (Gas Insulated Busbars)(OD) (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete replacement of the operating mechanism	132kV CBs	132kV CB (Air Insulated Busbars)(ID) (GM), 132kV CB (Air Insulated Busbars)(OD) (GM), 132kV CB (Gas Insulated Busbars)(ID) (GM) & 132kV CB (Gas Insulated Busbars)(OD) (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	132kV CBs	132kV CB (Air Insulated Busbars)(ID) (GM), 132kV CB (Air Insulated Busbars)(OD) (GM), 132kV CB (Gas Insulated Busbars)(ID) (GM) & 132kV CB (Gas Insulated Busbars)(OD) (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete factory refurbishment	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Installation of replacement windings	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Revise age to reflect time elapsed since Refurbishment undertaken
On site processing to recondition oil to remove moisture and acidity from windings	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cooling radiators	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Complete factory refurbishment	EHV Transformer	33kV Transformer (GM) & 66kV Transformer	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Installation of replacement windings	EHV Transformer	33kV Transformer (GM) & 66kV Transformer	i) Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs, Oil Test Modifier, DGA Test Modifier, FFA Test Modifier and Reliability Modifier; and ii) Revise age to reflect time elapsed since Refurbishment undertaken
On site processing to recondition oil to remove moisture and acidity from windings	EHV Transformer	33kV Transformer (GM) & 66kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing Oil Test Modifier

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected By Intervention
Replacement of bushings	EHV Transformer	33kV Transformer (GM) & 66kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cooling radiators	EHV Transformer	33kV Transformer (GM) & 66kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of gaskets & seals	EHV Transformer	33kV Transformer (GM) & 66kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of Tapchangers or full replacement of Tapchanger mechanism	EHV Transformer	33kV Transformer (GM) & 66kV Transformer	i) Reassess Health Score Modifier for Tapchanger subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Where Tapchanger is replaced: revise age of Tapchanger subcomponent, used in the calculation of Initial Health Score, to the age of the new Tapchanger
Complete factory refurbishment	132kV Transformer	132kV Transformer	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Installation of replacement windings	132kV Transformer	132kV Transformer	i) Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs, Oil Test Modifier, DGA Test Modifier, FFA Test Modifier and Reliability Modifier; and ii) Revise age to reflect time elapsed since Refurbishment undertaken
On site processing to recondition oil to remove moisture and acidity from windings	132kV Transformer	132kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing Oil Test Modifier
Replacement of bushings	132kV Transformer	132kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cooling radiators	132kV Transformer	132kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of gaskets & seals	132kV Transformer	132kV Transformer	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected By Intervention
Replacement of Tapchangers or full replacement of Tapchanger mechanism	132kV Transformer	132kV Transformer	i) Reassess Health Score Modifier for Tapchanger subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Where Tapchanger is replaced: revise age of Tapchanger subcomponent, used in the calculation of Initial Health Score, to the age of the new Tapchanger
Pole Strengthening (e.g. clamping a steelwork supporting bracket to an existing pole)	LV Poles	LV Poles	Reassess Health Score Modifier by reassessing Pole Decay/Deterioration Measured Condition Inputs
Small footprint steel masts: Replacement of individual steelwork members	LV Poles	LV Poles	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Pole Strengthening (e.g. clamping a steelwork supporting bracket to an existing pole)	HV Poles	6.6/11kV Poles & 20kV Poles	Reassess Health Score Modifier by reassessing Pole Decay/Deterioration Measured Condition Inputs
Small footprint steel masts: Replacement of individual steelwork members	HV Poles	6.6/11kV Poles & 20kV Poles	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Pole Strengthening (e.g. clamping a steelwork supporting bracket to an existing pole)	EHV Pole	33kV Pole & 66kV Pole	Reassess Health Score Modifier by reassessing Pole Decay/Deterioration Measured Condition Inputs
Small footprint steel masts: Replacement of individual steelwork members	EHV Pole	33kV Pole & 66kV Pole	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Painting of Tower	EHV Tower	33kV Tower & 66kV Tower	i) Reassess Health Score Modifier for Tower Paintwork subcomponent by reassessing Paintwork Condition Input; and ii) revise age of Tower Paintwork subcomponent, used in the calculation of Initial Health Score, to the time elapsed since the Tower was most recently painted
Replacement of individual steelwork members	EHV Tower	33kV Tower & 66kV Tower	Reassess Health Score Modifier for the Tower Steelwork subcomponent by reassessing relevant Observed Condition Inputs
Replacement of Tower foundations	EHV Tower	33kV Tower & 66kV Tower	Reassess Health Score Modifier for the Tower Foundation subcomponent by reassessing relevant Observed Condition Inputs
Painting of Tower	132kV Tower	132kV Tower	i) Reassess Health Score Modifier for Tower Paintwork subcomponent by reassessing Paintwork Condition Input ii) revise age of Tower Paintwork subcomponent, used in the calculation of Initial Health Score, to the time elapsed since the Tower was most recently painted

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected By Intervention
Replacement of individual steelwork members	132kV Tower	132kV Tower	Reassess Health Score Modifier for the Tower Steelwork subcomponent by reassessing relevant Observed Condition Inputs
Replacement of Tower foundations	132kV Tower	132kV Tower	Reassess Health Score Modifier for the Tower Foundation subcomponent by reassessing relevant Observed Condition Inputs
Re-engineering (replacement/refurbishment/relocation) of pressurising system equipment with the objective of reducing the normal operating fluid pressure in the cable system	EHV Cable (Gas)	33kV UG Cable (Gas) & 66kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Remaking existing joints and terminations in situ	EHV Cable (Gas)	33kV UG Cable (Gas) & 66kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Replacement of cable joints and terminations (including sealing ends)	EHV Cable (Gas)	33kV UG Cable (Gas) & 66kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Re-engineering (replacement/refurbishment/relocation) of pressurising system equipment with the objective of reducing the normal operating fluid pressure in the cable system	EHV Cable (Oil)	33kV UG Cable (Oil) & 66kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Remaking existing joints and terminations in situ	EHV Cable (Oil)	33kV UG Cable (Oil) & 66kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Replacement of cable joints and terminations (including sealing ends)	EHV Cable (Oil)	33kV UG Cable (Oil) & 66kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Re-engineering (replacement/refurbishment/relocation) of pressurising system equipment with the objective of reducing the normal operating fluid pressure in the cable system	132kV Cable (Gas)	132kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Remaking existing joints and terminations in situ	132kV Cable (Gas)	132kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Replacement of cable joints and terminations (including sealing ends)	132kV Cable (Gas)	132kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Re-engineering (replacement/refurbishment/relocation) of pressurising system equipment with the objective of reducing the normal operating fluid pressure in the cable system	132kV Cable (Oil)	132kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)
Remaking existing joints and terminations in situ	132kV Cable (Oil)	132kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected By Intervention
Replacement of cable joints and terminations (including sealing ends)	132kV Cable (Oil)	132kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input)

APPENDIX D

CALIBRATION - CONSEQUENCES OF FAILURE

D.1 Financial

D.1.1 Reference Financial Cost of Failure

The Reference Financial Cost of Failure is derived from an assessment of the likely repair costs incurred by the failure of the asset in each of its three failure modes[2]; incipient, degraded and catastrophic and relative proportions of each failure mode type (as a proportion of the total number of failures).

$$\begin{aligned}&\text{Reference Financial Cost of Failure} = \\&(\text{Proportion of Failures that are Incipient Failures} \times \text{Likely Cost of Incipient Failure}) \\&+ (\text{Proportion of Failures that are Degraded Failures} \times \text{Likely Cost of Degraded Failure}) \\&+ (\text{Proportion of Failures that are Catastrophic Failures} \times \text{Likely Cost of Catastrophic Failure})\end{aligned} \quad \text{(Eq. 25)}$$

Where:

- *Proportion of Failures that are Incipient Failures represents the expected number of Incipient Failures as a percentage of the total number of Functional Failures.*
- *Proportion of Failures that are Degraded Failures represents the expected number of Degraded Failures as a percentage of the total number of Functional Failures.*
- *Proportion of Failures that are Catastrophic Failures represents the expected number of Catastrophic Failures as a percentage of the total number of Functional Failures.*
- *Likely Cost of Failure is the cost to return the asset to service (which may extend to full replacement of the asset). This is determined based on the three failure modes considered:-*
    - *Incipient: The costs associated with addressing an Incipient Failure would not usually necessitate full asset replacement. Unless otherwise stated, a value equivalent to 10% of the Asset Replacement Costs[3] has been adopted.*
    - *Degraded: The costs associated with addressing a Degraded Failure would not usually necessitate full asset replacement; however the works would normally be over and above those associated with addressing an Incipient Failure. Unless otherwise stated, a value equivalent to 25% of the Asset Replacement Costs has been adopted.*
    - *Catastrophic: A failure of this type would necessitate full asset replacement. Asset Replacement Costs have therefore been adopted, unless otherwise stated.*

For Pressurised Cables (i.e. UG Cable (Gas) or UG Cable (Oil) assets), leakage of the pressurising fluid (i.e. gas or oil) that is addressed by topping up the fluid is considered, within the Functional Failures, as an Incipient Failure. The financial costs associated with Incipient Failures for these Asset Categories reflect the costs of such activity.

In establishing the generic and common PoF curves to describe the relative relationship between asset Health Score and PoF (Section 6.1) the number of failures by failure type

[2] As defined in Appendix A – Functional Failures
[3] As defined in Ofgem's expert view of industry costs as used in the cost assessment for the RIIO-ED1 Final Determination

(Incipient/Degraded/Catastrophic Failure) has been established in accordance with the definitions described in Section 4.2.

Based on this understanding the relative proportions of a failure being an Incipient, Degraded or Catastrophic Failure have been determined for each Asset Category as outlined in Table 211.

TABLE 211: REFERENCE FINANCIAL COST OF FAILURE

Asset Register Category	Relative Proportion Of Failure Modes (as a % of total Functional Failures)			Likely Cost of Failure			Reference Financial Cost of Failure
	I	D	C	I	D	C[4]	
LV Poles	20%	70%	10%	£136	£1,358	£1,358	£1,113
6.6/11kV Poles	20%	70%	10%	£194	£1,942	£1,942	£1,592
20kV Poles	20%	70%	10%	£233	£2,330	£2,330	£1,910
33kV Pole	20%	70%	10%	£250	£2,503	£2,503	£2,053
66kV Pole	20%	70%	10%	£377	£3,774	£3,774	£3,094
33kV Tower	80%	19.95%	0.05%	£4,309	£10,773	£43,094	£5,618
66kV Tower	80%	19.95%	0.05%	£8,074	£20,186	£80,742	£10,527
132kV Tower	80%	19.95%	0.05%	£9,336	£23,341	£93,364	£12,172
33kV Fittings	80%	15%	5%	£113	£282	£1,126	£189
66kV Fittings	80%	15%	5%	£145	£363	£1,450	£243
132kV Fittings	80%	15%	5%	£241	£603	£2,411	£404
33kV OHL (Tower Line) Conductor	0%	85%	15%	£0	£12,879	£25,758	£14,811
66kV OHL Conductor	0%	85%	15%	£0	£17,082	£34,164	£19,644
132kV OHL (Tower Line) Conductor	0%	85%	15%	£0	£14,772	£29,544	£16,988
HV Sub Cable	0%	0%	100%	£3,030	£7,575	£151,492	£151,492
33kV UG Cable (Non Pressurised)	0%	0%	100%	£2,634	£6,585	£26,340	£26,340
33kV UG Cable (Oil)	99%	0.09%	0.01%	£100	£6,585	£26,340	£108
33kV UG Cable (Gas)	99%	0.50%	0.50%	£100	£6,585	£26,340	£264
66kV UG Cable (Non Pressurised)	0%	0%	100%	£5,329	£13,323	£53,291	£53,291
66kV UG Cable (Oil)	99%	0.09%	0.01%	£100	£13,323	£53,291	£116
66kV UG Cable (Gas)	99%	0.50%	0.50%	£100	£13,323	£53,291	£432
132kV UG Cable (Non Pressurised)	0%	0%	100%	£9,093	£22,733	£90,934	£90,934
132kV UG Cable (Oil)	99%	0.09%	0.01%	£100	£22,733	£90,934	£129
132kV UG Cable (Gas)	99%	0.50%	0.50%	£100	£22,733	£90,934	£667
EHV Sub Cable	0%	0%	100%	£4,750	£11,875	£237,500	£237,500
132kV Sub Cable	0%	0%	100%	£8,000	£20,000	£400,000	£400,000
LV Circuit Breaker	15%	25%	60%	£500	£1,250	£5,000	£3,388
LV Pillar (ID)	15%	25%	60%	£697	£1,741	£6,965	£4,719
LV Pillar (OD at Substation)	15%	25%	60%	£758	£1,895	£7,581	£5,136
LV UGB & LV Pillars (OD not at Substation)	15%	25%	60%	£421	£1,053	£4,213	£2,854
LV Board (WM)	15%	25%	60%	£962	£2,406	£9,624	£6,520
LV Board (X-type Network) (WM)	15%	25%	60%	£1,136	£2,839	£11,357	£7,694
6.6/11kV CB (GM) Primary	45%	50%	5%	£2,870	£7,176	£28,705	£6,315
6.6/11kV CB (GM) Secondary	15%	25%	60%	£855	£2,137	£8,550	£5,792
6.6/11kV Switch (GM)	15%	25%	60%	£647	£1,618	£6,471	£4,384
6.6/11kV RMU	15%	25%	60%	£1,209	£3,022	£12,089	£8,190
6.6/11kV X-type RMU	15%	25%	60%	£1,636	£4,090	£16,358	£11,083
20kV CB (GM) Primary	45%	50%	5%	£3,596	£8,990	£35,961	£7,911
20kV CB (GM) Secondary	15%	25%	60%	£886	£2,216	£8,863	£6,005
20kV Switch (GM)	15%	25%	60%	£750	£1,875	£7,500	£5,081
20kV RMU	15%	25%	60%	£1,231	£3,079	£12,315	£8,343
33kV CB (Air Insulated Busbars)(ID) (GM)	45%	50%	5%	£5,491	£13,728	£54,914	£12,081
33kV CB (Air Insulated Busbars)(OD) (GM)	45%	50%	5%	£6,761	£16,903	£67,610	£14,874

Asset Register Category	Relative Proportion Of Failure Modes (as a % of total Functional Failures)			Likely Cost of Failure			Reference Financial Cost of Failure
	I	D	C	I	D	C[4]	
33kV CB (Gas Insulated Busbars)(ID) (GM)	45%	50%	5%	£8,318	£20,794	£83,176	£18,299
33kV CB (Gas Insulated Busbars)(OD) (GM)	45%	50%	5%	£8,318	£20,794	£83,176	£18,299
33kV Switch (GM)	45%	50%	5%	£3,881	£9,702	£38,807	£8,537
33kV RMU	45%	50%	5%	£9,590	£23,976	£95,903	£21,099
66kV CB (Air Insulated Busbars)(ID) (GM)	45%	50%	5%	£10,946	£27,365	£109,459	£24,081
66kV CB (Air Insulated Busbars)(OD) (GM)	45%	50%	5%	£17,500	£43,750	£175,000	£38,500
66kV CB (Gas Insulated Busbars)(ID) (GM)	45%	50%	5%	£19,741	£49,353	£197,413	£43,431
66kV CB (Gas Insulated Busbars)(OD) (GM)	45%	50%	5%	£19,741	£49,353	£197,413	£43,431
132kV CB (Air Insulated Busbars)(ID) (GM)	45%	50%	5%	£30,682	£76,705	£306,821	£67,501
132kV CB (Air Insulated Busbars)(OD) (GM)	45%	50%	5%	£14,446	£36,115	£144,461	£31,781
132kV CB (Gas Insulated Busbars)(ID) (GM)	45%	50%	5%	£63,902	£159,755	£639,021	£140,585
132kV CB (Gas Insulated Busbars)(OD) (GM)	45%	50%	5%	£63,902	£159,755	£639,021	£140,585
6.6/11kV Transformer (GM)	15%	25%	60%	£1,142	£2,856	£11,422	£7,739
20kV Transformer (GM)	15%	25%	60%	£1,301	£3,251	£13,005	£8,811
33kV Transformer (GM)	45%	50%	5%	£33,182	£82,954	£331,816	£73,000
66kV Transformer	45%	50%	5%	£51,001	£127,504	£510,015	£112,203
132kV Transformer	45%	50%	5%	£99,514	£248,786	£995,144	£218,932

[4] These are based on Ofgem's expert view of industry costs from the final determination cost assessment process from RIIO-ED1. For cables and conductor are expressed on a per km basis; however the lengths replaced under fault conditions are typically less than that. Further, the cost of replacing these shorter lengths of cable or conductor is not directionally proportional to the cost of replacing much greater lengths as part of planned replacements works (i.e. the basis on which replacement costs are established). For the purposes of establishing the Reference Financial Consequence it is assumed that 10% of the costs incurred per km of activity would be incurred in carrying out a repair (typical length of 50m with a factor of 2 to reflect the lower efficiency for these types of works). For subsea cable the typical length replaced during a repair is 500m and therefore the cost of a Catastrophic Failure has been assumed to be 50% of the costs incurred per km (i.e. with no further efficiency adjustment factor).

D.1.2 Financial Consequence Factors

As described in Section 7.3.3 the resulting Reference Financial Cost of Failure value can then be modified for individual assets within an Asset Category based on the application of a Type Financial Factor and/or an Access Financial Factor to result in a Financial CoF that reflects the characteristics of an individual asset of that type.

D1.2.1 TYPE FINANCIAL FACTORS

Type Financial Factors other than 1, may be applied to those Asset Categories shown in Table 212, using the Type Financial Factor criteria shown. For all other Asset Categories this Factor shall be set to 1. Similarly the default value of the Type Financial Factor shall be 1.

TABLE 212: TYPE FINANCIAL FACTORS

Asset Register Category	Type Financial Factor Criteria	Type Financial Factor
LV Poles	Pole (excluding terminal poles)	1
	Pole (terminal poles)	1.2
	Steel Poles	2
LV Board (WM)	Non Asbestos clad	1
	Asbestos clad	2
LV Board (X-type Network) (WM)	Non Asbestos clad	1
	Asbestos clad	2
6.6/11kV Poles	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
20kV Poles	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
6.6/11kV Transformer (GM)	≥750kVA	1.15
	≥500kVA and <750kVA	1
	<500kVA	0.85
20kV Transformer (GM)	≥750kVA	1.15
	≥500kVA and <750kVA	1
	<500kVA	0.85
33kV Pole	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
66kV Pole	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
33kV Tower	Suspension	1
	Tension	1.05
	Terminal	1.1
66kV Tower	Suspension	1
	Tension	1.05
	Terminal	1.1

Asset Register Category	Type Financial Factor Criteria	Type Financial Factor
33kV Transformer (GM)	33/20kV, >20MVA CMR equivalent	1.25
	33/20kV, >10MVA and ≤20MVA CMR equivalent	1.1
	33/20kV, ≤10MVA CMR equivalent	1
	33/11 or 6.6kV, >20MVA CMR equivalent	1.1
	33/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1
	33/11 or 6.6kV, ≤10MVA CMR equivalent	0.9
66kV Transformer (GM)	66/20kV, >20MVA CMR equivalent	1.25
	66/20kV, >10MVA and ≤20MVA CMR equivalent	1.1
	66/20kV, ≤10MVA CMR equivalent	1
	66/33kV	1.1
	66/11/11kV	1.1
	66/11 or 6.6kV, >20MVA CMR equivalent	1.1
	66/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1
	66/11 or 6.6kV, ≤10MVA CMR equivalent	0.9
33kV Fittings	Suspension	1
	Tension	2
66kV Fittings	Suspension	1
	Tension	2
132kV Fittings	Suspension	1
	Tension	2
132kV Tower	Suspension	1
	Tension	1.05
	Terminal	1.1
132kV Transformer (GM)	132/66kV, ≤60MVA	1.05
	132/66kV, >60MVA	1.15
	132/33kV, ≤60MVA	0.9
	132/33kV, >60MVA	1
	132/11/11kV	1.1
	132/11kV	0.85
	132/20kV	0.95
	132/20/20kV	1.1

D1.2.2 ACCESS FINANCIAL FACTORS

Access Financial Factors other than 1, may be applied to those Asset Categories shown in Tables 213 and 214, using the criteria shown. For all other Asset Categories this factor shall be set to 1. Similarly the default value of Access Financial Factor shall be 1.

TABLE 213: ACCESS FACTOR: OHL

Asset Category	Access Factor	
	Type A Criteria - Normal Access (& Default Value)	Type B Criteria - Major Crossing (e.g. associated span crosses railway line, major road, large waterway etc.)
LV OHL Support	1	3
HV OHL Support - Poles	1	3
EHV OHL Support - Poles	1	3
EHV OHL Support - Towers	1	1.5
EHV OHL Fittings (Tower Lines)	1	2
EHV OHL Conductors (Tower Lines)	1	2
132kV OHL Support - Tower	1	1.5
132kV OHL Fittings (Tower Lines)	1	2
132kV OHL Conductors (Tower Lines)	1	2

TABLE 214: ACCESS FACTOR: SWITCHGEAR & TRANSFORMER ASSETS

Asset Category	Access Factor		
	Type A Criteria - Normal Access (& Default Value)	Type B Criteria - Constrained Access or Confined Working Space	Type C Criteria - Underground substation
LV Switchgear	1	1.25	1.7
HV Transformer (GM)	1	1.25	2
HV Switchgear (GM) - Distribution	1	1.25	1.7
HV Switchgear (GM) - Primary	1	1.15	1.3
EHV Switchgear (GM)	1	1.1	1.25
132kV CBs	1	1.1	1.2
EHV Transformer	1	1.1	1.35
132kV Transformer	1	1.1	1.25

D.2 Safety

D.2.1 Reference Safety Cost of Failure

Each Asset Category has an associated reference safety probability based on applying the appropriate value (of preventing a LTA or DSI) to the corresponding probability that each of these events occurs, categorised as follows:-

i) LTA;
ii) DSI to member of staff; and
iii) DSI to member of the public.

These values have been derived from an assessment of both disruptive and non-disruptive failure probabilities for these events based on bottom up assessments of faults. The results of this analysis are shown in Table 215. These have been evaluated for each Asset Category using the following event tree:-

i) probability that event could be hazardous;
ii) probability that person who is present suffers the effect; and
iii) probability that affected person is present when fault occurs.

The Reference Safety Cost of Failure is derived initially by applying the probability that a failure could result in an accident, serious injury or fatality to the cost of a Lost Time Accident (LTA) or Death or Serious Injury (DSI) as appropriate.

$$\text{Reference Safety Cost of Failure} = \left((\text{Probability of LTA} \times \text{Cost of LTA}) + \left((\text{Probability of DSI to the Public} + \text{Probability of DSI to the Staff})\right) \times (\text{Cost of DSI})\right) \times \text{Disproportion Factor} \quad \text{(Eq. 28)}$$

Where:

- *Cost of LTA is the Reference Cost of a Lost Time Accident as shown in Table 216*
- *Cost of DSI is the Reference Cost of a Death or Serious Injury as shown in Table 216*
- *Disproportion Factor is explained later in this section*

TABLE 215: REFERENCE SAFETY PROBABILITIES

Asset Register Category	PROBABILITY OF EVENT PER ASSET FAILURE		
	Lost Time Accident	Death or Serious Injury to public	Death or Serious Injury to staff
LV Poles	0.000816	0.00003264	0.00001632
6.6/11kV Poles	0.000272	0.00001088	0.00000544
20kV Poles	0.000272	0.00001088	0.00000544
33kV Pole	0.000272	0.00001088	0.00000544
66kV Pole	0.000272	0.00001088	0.00000544
33kV Tower	0.000136	0.00000544	0.0000272
66kV Tower	0.000136	0.00000544	0.0000272
132kV Tower	0.000136	0.00000544	0.0000272
33kV Fittings	0.000544	0.00002176	0.0001088
66kV Fittings	0.000544	0.00002176	0.0001088
132kV Fittings	0.000544	0.00002176	0.0001088
33kV OHL (Tower Line) Conductor	0.000544	0.00002176	0.0001088
66kV OHL Conductor	0.000544	0.00002176	0.0001088
132kV OHL (Tower Line) Conductor	0.000544	0.00002176	0.0001088
HV Sub Cable	0.00000075	0.000000075	0.000000075
33kV UG Cable (Non Pressurised)	0.00000075	0.000000075	0.000000075
33kV UG Cable (Oil)	0.00000075	0.000000075	0.000000075
33kV UG Cable (Gas)	0.00000075	0.000000075	0.000000075
66kV UG Cable (Non Pressurised)	0.00000075	0.000000075	0.000000075
66kV UG Cable (Oil)	0.00000075	0.000000075	0.000000075
66kV UG Cable (Gas)	0.00000075	0.000000075	0.000000075
132kV UG Cable (Non Pressurised)	0.00000075	0.000000075	0.000000075
132kV UG Cable (Oil)	0.00000075	0.000000075	0.000000075
132kV UG Cable (Gas)	0.00000075	0.000000075	0.000000075
EHV Sub Cable	0.00000075	0.000000075	0.000000075

Asset Register Category	PROBABILITY OF EVENT PER ASSET FAILURE		
	Lost Time Accident	Death or Serious Injury to public	Death or Serious Injury to staff
132kV Sub Cable	0.00000075	0.000000075	0.000000075
LV Circuit Breaker	0.00004916	0.000434412	0.000370311
LV Pillar (ID)	0.00004916	0.000434412	0.000370311
LV Pillar (OD at Substation)	0.00004916	0.000434412	0.000370311
LV UGB & LV Pillars (OD not at Substation)	0.00005193	0.000458912	0.000391196
LV Board (WM)	0.00004916	0.000434412	0.000370311
LV Board (X-type Network) (WM)	0.00004916	0.000434412	0.000370311
6.6/11kV CB (GM) Primary	0.000260274	0.000115	0.001960616
6.6/11kV CB (GM) Secondary	0.0000260274	0.00023	0.000196062
6.6/11kV Switch (GM)	0.0000260274	0.00023	0.000196062
6.6/11kV RMU	0.0000260274	0.00023	0.000196062
6.6/11kV X-type RMU	0.0000260274	0.00023	0.000196062
20kV CB (GM) Primary	0.000260274	0.000115	0.001960616
20kV CB (GM) Secondary	0.0000260274	0.00023	0.000196062
20kV Switch (GM)	0.0000260274	0.00023	0.000196062
20kV RMU	0.0000260274	0.00023	0.000196062
33kV CB (Air Insulated Busbars)(ID) (GM)	0.000260274	0.000115	0.001960616
33kV CB (Air Insulated Busbars)(OD) (GM)	0.000260274	0.000115	0.001960616
33kV CB (Gas Insulated Busbars)(ID) (GM)	0.000260274	0.000115	0.001960616
33kV CB (Gas Insulated Busbars)(OD) (GM)	0.000260274	0.000115	0.001960616
33kV Switch (GM)	0.000260274	0.000115	0.001960616
33kV RMU	0.000260274	0.000115	0.001960616
66kV CB (Air Insulated Busbars)(ID) (GM)	0.000260274	0.000115	0.001960616
66kV CB (Air Insulated Busbars)(OD) (GM)	0.000260274	0.000115	0.001960616
66kV CB (Gas Insulated Busbars)(ID) (GM)	0.000260274	0.000115	0.001960616
66kV CB (Gas Insulated Busbars)(OD) (GM)	0.000260274	0.000115	0.001960616
132kV CB (Air Insulated Busbars)(ID) (GM)	0.000416438	0.0000575	0.003136986
132kV CB (Air Insulated Busbars)(OD) (GM)	0.000416438	0.0000575	0.003136986
132kV CB (Gas Insulated Busbars)(ID) (GM)	0.000416438	0.0000575	0.003136986
132kV CB (Gas Insulated Busbars)(OD) (GM)	0.000416438	0.0000575	0.003136986
6.6/11kV Transformer (GM)	0.0000260274	0.00023	0.000196062
20kV Transformer (GM)	0.0000260274	0.00023	0.000196062
33kV Transformer (GM)	0.000260274	0.000115	0.001960616
66kV Transformer	0.000260274	0.000115	0.001960616
132kV Transformer	0.000416438	0.0000575	0.003136986

The Reference Safety Costs for ‘death or serious injury’ and ‘accident’ are based on the HSE’s GB cross-industry wide appraisal values for fatal injuries and for non-fatal injuries. These represent a quantification of the societal value of preventing an LTA or DSI.

TABLE 216: REFERENCE SAFETY COST

Reference safety cost	Value (£)
Lost Time Accident	£9,000
Death or Serious Injury to public	£1,600,000
Death or Serious Injury to staff	

In addition, a disproportion factor recognising the high risk nature of the electricity distribution industry is applied. Such disproportion factors are described by the HSE guidance when identifying reasonably practicable costs of mitigation. This value is not mandated by the HSE but they state that they believe that “the greater the risk, the more should be spent in reducing it, and the greater the bias should be on the side of safety”. They also suggest that the extent of the bias must be argued in the light of all the circumstances and that the factor is unlikely to be higher than 10.

In the Methodology, the factor is set to 6.25, which serves to set the current value of a DSI at £10m.

TABLE 217: REFERENCE SAFETY COST - DISPROPORTION FACTOR

Reference safety cost	Value
Disproportion Factor	6.25

D.2.2 Safety Consequence Factors

As described in Section 7.4.3 the Safety CoF can then be derived for individual assets by the application of a Type Safety Factor and/or a Location Safety Factor so that it reflects the characteristics of an individual asset. These are detailed by Asset Category Grouping in Tables 218 and 219. Where a Type or Location rating has not been determined, then the Medium (Default) rating shall be assumed.

D.2.2.1 SWITCHGEAR, TRANSFORMERS & OVERHEAD LINES

Under the Electricity Safety Quality and Continuity Regulations 2002 (ESQCR), risk assessments must be carried out on substation sites and overhead lines to assess the risk of interference, vandalism or unauthorised access to the asset by the public.

The overall risk value is built from the following components:-

- Type (Risk that the asset presents to the public by its characteristics and particular situation); and
- Location (Proximity to areas that may affect its likelihood of trespass or interference).

The overall Safety CoF Factors for Switchgear, Transformers and Overhead Lines are determined by these Type and Location Risk Ratings as shown Table 218.

TABLE 218: SAFETY CONSEQUENCE FACTOR – SWITCHGEAR, TRANSFORMERS & OVERHEAD LINES

Safety Consequence Factor – Switchgear, Transformers & Overhead Lines		TYPE RISK RATING		
		Low	Medium (Default)	High
LOCATION RISK RATING	Low	0.7	0.9	1.2
	Medium (Default)	0.9	1	1.4
	High	1.2	1.4	1.6

D.2.2.3 CABLES

For cables there is a significant level of inherent safety of these asset types given the majority of the assets are buried. However it is considered appropriate to modify the Reference Safety Cost of Failure to account for those situations where cables are exposed above ground, e.g. cable structures or where cables terminate onto overhead line supports.

The overall Safety CoF Factors for cable asset types are determined according to Table 219.

TABLE 219: SAFETY CONSEQUENCE FACTOR - CABLES

SAFETY CONSEQUENCE FACTOR - CABLES	
Buried	1.0
Exposed (e.g. cable structure)	2.0

D.3 Environmental

D.3.1 Reference Environmental Cost of Failure

The Environmental CoF value for an asset is derived using a Reference Environmental Cost of Failure, which is modified for individual assets using asset-specific factors. This is based on an assessment of the typical environmental impacts of a failure of the asset in each of its three failure modes; incipient, degraded and catastrophic. The Reference Environmental Cost of Failure that shall be used for each Asset Category is shown in Table 220.

This assessment considers four factors;

i) Volume of oil lost;
ii) Volume of SF_6 lost;
iii) Probability of the event leading to a fire; and
iv) Quantity of waste produced.

$$\begin{aligned}
&\textbf{Reference Environmental Cost of Failure} = \\
&(\textbf{\% of Incipient Failures}) \times ((\textbf{Volume of oil lost per Incipient failure} \times \\
&\textbf{Environmental cost per litre oil (£/litre)}) + (\textbf{Volume of SF}_6\textbf{ lost per Incipient failure} \times \\
&\textbf{Environmental cost per kg of SF}_6\textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Incipient failure} \times \textbf{Environmental cost of fire}) + \\
&(\textbf{Quantity of waste produced per incipient failure} \times \textbf{Environmental cost per tonne waste (£/t)})) + \\
&(\textbf{\% of Degraded Failures}) \times ((\textbf{Volume of oil lost per Degraded failure} \times \\
&\textbf{Environmental cost per litre oil (£/litre)}) + (\textbf{Volume of SF}_6\textbf{ lost per Degraded failure} \times \\
&\textbf{Environmental cost per kg of SF}_6\textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Degraded failure} \times \textbf{Environmental cost of fire}) + \\
&(\textbf{Quantity of waste produced per Degraded failure} \times \textbf{Environmental cost per tonne waste (£/t)})) + \\
&(\textbf{\% of Catastrophic Failures}) \times ((\textbf{Volume of oil lost per Catastrophic failure} \times \\
&\textbf{Environmental cost per litre oil (£/litre)}) + (\textbf{Volume of SF}_6\textbf{ lost per Catastrophic failure} \times \\
&\textbf{Environmental cost per kg of SF}_6\textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Catastrophic failure} \times \textbf{Environmental cost of fire}) + \\
&\textbf{Quantity of waste produced per Catastophic failure} \times \textbf{Environmental cost per tonne waste (£/t)})))
\end{aligned} \quad \text{(Eq. 30)}$$

Where:

- *Environmental cost per litre oil = £36.08/litre*
- *Environmental cost per kg of SF_6 lost = £240/kg*
  Which is derived from:
  - *Traded carbon price = £10.04/tonne*
  - *Cost of SF_6 loss c/w cost of carbon = 23,900kg(CO_2)/kg*
- *Environmental cost of fire = £5,000*
- *Environmental cost per tonne waste = £150/tonne*

The sources for the above costs are shown in Table 17 in Section 7.5.2.

The detailed breakdown of the Reference Environmental Cost of Failure by Asset Category is shown in Table 220.

TABLE 220: REFERENCE ENVIRONMENTAL COST OF FAILURE

Asset Category	Average volume of oil lost per failure (litres)			Average volume of SF6 lost per failure (kg)			Average probability that failure results in a fire			Average quantity of waste per failure (t)			Failures as % of All Failures			Reference Environmental Consequence
	I	D	C	I	D	C	I	D	C	I	D	C	I	D	C	
LV OHL Support	0	0	0	0	0	0	0	0	0.0005	0.5	0.5	0.5	49%	49%	2%	£75
HV OHL Support - Poles	0	0	0	0	0	0	0	0	0.0005	0.5	0.5	0.5	49%	49%	2%	£75
EHV OHL Support - Poles	0	0	0	0	0	0	0	0	0.0005	0.5	0.5	0.5	49%	49%	2%	£75
EHV UG Cable (Gas)	0	0	0	0	0	0	0	0	0.001	0.2	0.2	10	45%	54%	1%	£45
132kV UG Cable (Gas)	0	0	0	0	0	0	0	0	0.001	0.3	0.3	15	45%	54%	1%	£67
EHV UG Cable (Oil)	120	120	1200	0	0	0	0	0	0.001	0.8	0.8	40	45%	54%	1%	£4,898
132kV UG Cable (Oil)	150	150	1500	0	0	0	0	0	0.001	1.2	1.2	60	45%	54%	1%	£6,167
LV Switchgear	0	0	0	0	0	0	0	0.0002	0.005	0.01	0.1	0.25	50%	30%	20%	£18
LV UGB	0	0	0	0	0	0	0	0.0002	0.05	0.01	0.1	0.5	50%	30%	20%	£71
HV Switchgear (GM) - Primary	10	50	150	0.2	0.4	0.7	0	0.0005	0.01	0.1	0.2	0.5	65%	30%	5%	£1,141
HV Switchgear (GM) - Distribution	10	50	150	0.1	0.2	0.5	0	0.0005	0.01	0.1	0.2	0.5	65%	30%	5%	£1,108
EHV Switchgear (GM)	25	125	250	0.2	0.5	1	0	0.0005	0.01	0.2	0.5	2	70%	20%	10%	£2,589
132kV CBs	50	250	1000	0.5	1	2	0	0.0005	0.01	0.3	2	10	70%	20%	10%	£7,102
HV Transformer (GM)	20	100	300	0	0	0	0.0002	0.002	0.02	1	2	5	50%	40%	10%	£3,171
EHV Transformer	50	250	2500	0	0	0	0.0002	0.002	0.02	0.2	3	30	50%	40%	10%	£14,190
132kV Transformer	100	500	5000	0	0	0	0.0002	0.002	0.02	0.5	10	100	50%	40%	10%	£29,212
EHV UG Cable (Non Pressurised)	0	0	0	0	0	0	0	0	0.001	0	0	4	0%	0%	100%	£605
132kV UG Cable (Non Pressurised)	0	0	0	0	0	0	0	0	0.001	0	0	6	0%	0%	100%	£905
Submarine Cables	0	0	0	0	0	0	0	0	0	0	0	20	0%	0%	100%	£3,000
EHV OHL Support - Towers	0	0	0	0	0	0	0	0	0.001	0	0	1	0%	0%	100%	£155
132kV OHL Support - Tower	0	0	0	0	0	0	0	0	0.001	0	0	1	0%	0%	100%	£155
EHV OHL Fittings	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£80
132kV OHL Fittings	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£80
EHV OHL Conductor (Tower Lines)	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£80
132kV OHL Conductor (Tower Lines)	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£80

D.3.2 Environmental Consequence Factors

As described in Section 7.5.3 the resulting Reference Environmental Cost of Failure can then be modified for individual assets within that type based on the application of a Type Environmental Factor, Size Environmental Factor and/or a Location Environmental Factor to result in an Environmental CoF that reflects the characteristics of an individual asset of that type. These are shown in Table 221 by Asset Category Grouping.

The Type Environmental Factor for switchgear shall consider whether the individual asset contains oil or SF_6, either as an interruption medium or insulation medium,

TABLE 221: TYPE ENVIROMENTAL FACTOR

Type environment factor	Oil	SF_6	Neither	Default
HV Switchgear (GM) - Primary	0.94	0.08	0.02	0.94
HV Switchgear (GM) - Distribution	0.97	0.05	0.02	0.97
EHV Switchgear (GM)	0.97	0.06	0.03	0.97
132kV CBs	0.97	0.06	0.03	0.97

All other Asset Categories are set to a default Type Environmental Factor of 1.

TABLE 222: SIZE ENVIRONMENTAL FACTOR

Asset Register Category	Size Environmental Factor Criteria	Size Environmental Factor
6.6/11kV Transformer (GM)	≥750kVA	1
	≥500kVA and <750kVA	1
	<500kVA	0.6
20kV Transformer (GM)	≥750kVA	1
	≥500kVA and <750kVA	1
	<500kVA	0.6
33kV Transformer (GM)	33/20kV, >20MVA CMR equivalent	1.6
	33/20kV, >10MVA and ≤20MVA CMR equivalent	1
	33/20kV, ≤10MVA CMR equivalent	0.7
	33/11 or 6.6kV, >20MVA CMR equivalent	1.6
	33/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1
	33/11 or 6.6kV, ≤10MVA CMR equivalent	0.7
66kV Transformer (GM)	66/20kV, >20MVA CMR equivalent	1.6
	66/20kV, >10MVA and ≤20MVA CMR equivalent	1
	66/20kV, ≤10MVA CMR equivalent	0.7
	66/33kV	1.2
	66/11/11kV	1.2
	66/11 or 6.6kV, >20MVA CMR equivalent	1.6
	66/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1

Asset Register Category	Size Environmental Factor Criteria	Size Environmental Factor
	66/11 or 6.6kV, ≤10MVA CMR equivalent	0.7
132kV Transformer (GM)	132/66kV, ≤60MVA	0.8
	132/66kV, >60MVA	1
	132/33kV, ≤60MVA	0.8
	132/33kV, >60MVA	1
	132/11/11kV	0.8
	132/11kV	0.7
	132/20kV	0.7
	132/20/20kV	0.8

The default value for Size Environmental Factor is 1. The default value shall be applied to all those Asset Categories that are not shown in Table 222.

TABLE 223: LOCATION ENVIRONMENTAL FACTOR

Asset Register Category	Proximity Factor				Bunding Factor	
	Not Close to Water Course (>120m) or No Oil	Moderately Close to Water Course (between 80m and 120m)	Close to Water Course (between 40m and 80m)	Very Close to Water Course (<40m)	Bunded	Not bunded
EHV UG Cable (Oil)	0.8	1	1.5	2.5	0.5	1
132kV UG Cable (Oil)	0.8	1	1.5	2.5	0.5	1
HV Switchgear (GM) - Primary	0.8	1	1.5	2.5	0.5	1
HV Switchgear (GM) - Distribution	0.8	1	1.5	2.5	0.5	1
EHV Switchgear (GM)	0.8	1	1.5	2.5	0.5	1
132kV CBs	0.8	1	1.5	2.5	0.5	1
HV Transformer (GM)	0.8	1	1.5	2.5	0.5	1
EHV Transformer	0.8	1	1.5	2.5	0.5	1
132kV Transformer	0.8	1	1.5	2.5	0.5	1

The default value for Location Environmental Factor is 1. The default value shall be applied to all those Asset Categories that are not shown in Table 223.

D.4 Network Performance

D.4.1 Reference Network Performance Cost of Failure (LV & HV)

The Reference Network Performance Cost of Failure is based on an assessment of the typical network costs incurred by a failure of the asset as measured through its impact in relation to the number of customers interrupted and the duration of those interruptions. For regulatory purposes, this is captured via the IIS mechanism.

TABLE 224: COSTS USED IN DERIVATION OF NETWORK PERFORMANCE REFERENCE COST OF FAILURE

Parameter	£ (at 2012/13 prices)
Cost of CML	£0.38*
Cost of CI	£15.44*

* *Pre-IQI values for IIS incentive rates*

For each Asset Category, an assessment is made of:-

i) the typical number of customers interrupted by a failure; and
ii) the typical duration of any loss of supply to customers.

This assessment considers two time periods that reflect the initial fault impact and response activity and the subsequent time to fully restore supplies and restore the asset to its pre-fault state, as illustrated in Figure 29.

FIGURE 29: NETWORK PERFORMANCE - LV & HV

This considers:-

i) the proportion of failures that result in an interruption to supply. This is taken as being the proportion of total failures that are Degraded Failures or Catastrophic Failures. It is assumed that remedial works to address Incipient Failures can be undertaken as planned works and therefore that mitigation measures would be employed to avoid any Network Performance impact;
ii) the typical number of customers connected to the section of distribution network that is affected by failure of the asset (the Reference Number of Connected Customers);

iii) the typical number of customers whose supply is restored through immediate switching. This is expressed as a proportion of the Reference Number of Connected Customers. A customer's supply is only considered as being interrupted where supply is not restored immediately, which is consistent with the IIS mechanism;
iv) the typical time to restore further supplies through manual switching;
v) the typical number of customers whose supplies are restored following completion of manual switching. This is expressed as a proportion of the Reference Number of connected Customers (and represents the total number of customers whose supplies are restored by immediate switching or manual switching); and
vi) the typical time to repair the failure (and restore any remaining supplies that were not restored by manual switching).

In evaluating the Reference Network Performance Cost of Failure:-
i) the number of customers interrupted per failure is multiplied by the relevant cost of a customer interruption (Cost of CI); and
ii) the number of customer minutes without supply per failure is evaluated; and multiplied by the relevant cost of a customer minute lost (Cost of CML)

to produce a cost per failure for a given Reference Number of Connected Customers. This is shown in Eq. 34.

$$\begin{aligned}&\textbf{Reference Network Performance Cost of Failure} =\\&[(\textbf{Cost of CML} \times 60 \times \textbf{Reference Number of CC} \times \textbf{Switching Time} \times (100\%\\&\qquad - \%\ \textbf{of CC restored through immediate switching}))\\&+ (\textbf{Cost of CML} \times 60 \times \textbf{Reference Number of CC} \times \textbf{Restoration Time} \times (100\% -\\&\%\ \textbf{of CC restored after manual switching}))\\&+ (\textbf{Cost of CI} \times \textbf{Reference Number of CC} \times (100\% -\\&\%\ \textbf{of CC restored through immediate switching}))] \times \%\ \textbf{of failures that result in}\\&\textbf{interruption to supply}\end{aligned} \qquad \text{(Eq. 34)}$$

Where:

- *CC = Connected Customers*
- *Switching Time and Restoration Time are durations (in hours)*

Table 225 summarises the parameters used in evaluating the Reference Network Performance Cost of Failure for each HV and LV Asset Category.

TABLE 225: REFERENCE NETWORK PERFORMANCE COST OF FAILURE FOR LV & HV ASSETS

Asset Category	Reference Number of Connected Customers	Proportion of connected customers restored through immediate (< 3min) switching	Proportion of customers restored After manual switching	Manual switching time (hours)	Typical repair time (hours)	Proportion of failures that result in interruption to supply	Reference Network Performance Cost (£)
LV OHL Support	80	0%	0%	1	5	10%	£1,218
HV OHL Support - Poles	800	60%	94%	0.5	4	10%	£1,297
HV Transformer (GM)	200	0%	85%	0.5	4	60%	£4,862
HV Switchgear (GM) - Distribution	800	60%	94%	0.5	4	60%	£7,780
HV Switchgear (GM) - Primary	1000	60%	94%	0.5	4	60%	£9,725
LV Circuit Breaker	200	0%	85%	1	7	100%	£12,436
LV Pillar	200	25%	89%	1	7	100%	£9,247
LV UGB	80	25%	89%	1	7	100%	£3,699
LV Board (WM)	200	25%	89%	1	7	100%	£9,247
HV Sub Cable	800	40%	60%	2	18	100%	£160,627

D.4.2 Network Performance Factors (LV & HV)

As described in Section 7.6.2.2 the Reference Network Performance Cost of Failure can then be modified on an asset by asset basis as shown in Eq. 35.

$$\begin{aligned}&\text{Network Performance Cost of Failure} = \\&\text{Reference Network Performance Cost of Failure} \times \\&\text{Network Performance Consequence Factor}\end{aligned} \quad \text{(Eq. 35)}$$

Where:

$$\begin{aligned}&\text{Network Performance Consequence Factor} \\&\qquad = \text{Customer Factor} \times \text{Customer Sensitivity Factor}\end{aligned} \quad \text{(Eq. 36)}$$

Customer Factor

This Factor is used to reflect the number of customers impacted by failure of an individual asset, relative to the reference number of customers used in the derivation of the Reference Network Performance Cost of Failure.

This is applied as a direct Factor, i.e. not via a lookup table. For example, if the number of customers used in the derivation of the Reference Network Performance Cost of Failure is 100, but for a specific example it is 80 (or 120), then a modifying factor of 0.8 (or 1.2) would be applied.

$$\text{Customer Factor} = \frac{\text{No. of Customers}}{\text{Reference No. of Customers}} \quad \text{(Eq. 37)}$$

Where a DNO identifies that the customers fed by an individual asset have an exceptionally high demand per customer, then the No. of Customers used in the derivation of Eq. 37 may be derived by applying an adjustment to the actual number of customers fed by the asset as shown in Table 18. This adjustment recognises that for high demand customers the cost of a customer interruption and a customer minute lost may not reflect the value of lost load to the customer. DNOs can elect whether or not to apply this adjustment within their implementation of the Methodology.

TABLE 226: CUSTOMER NUMBER ADJUSTMENT FOR LV & HV ASSETS WITH HIGH DEMAND CUSTOMERS

Maximum Demand on Asset / Total Number of Customers fed by the Asset (kVA per Customer)	No. of Customers to be used in the derivation of Customer Factor
< 50	1 x actual number of customers fed by the asset
≥ 50 and < 100	25 x actual number of customers fed by the asset
≥ 100 and < 500	100 x actual number of customers fed by the asset
≥ 500 and < 1000	250 x actual number of customers fed by the asset
≥ 1000 and < 2000	500 x actual number of customers fed by the asset
≥ 2000	1000 x actual number of customers fed by the asset

The default value for the Customer Factor is 1.

Customer Sensitivity Factor

The Customer Sensitivity Factor is used to reflect circumstances where the customer impact is increased due to customer reliance on electricity (e.g. vulnerable customers). DNOs may use this factor at their discretion in order to modify the Network Performance Consequence Factor.

The default value for the Customer Sensitivity Factor is 1. Individual DNOs are provided with the freedom within the Methodology to apply a Customer Sensitivity Factor, other than the default, to the Network Performance Consequences (LV & HV) for any asset, provided that:-

iii) the individual DNO documents all instances where a Customer Sensitivity Factor different from the default is applied within their individual Network Asset Indices Methodology; and

iv) The Customer Sensitivity Factor shall not be less than 1, nor greater than 2.

D.4.3 Reference Network Performance Cost of Failure (EHV & 132kV)

For EHV and 132kV assets the Reference Network Performance Cost of Failure is based on an assessment of the amount of Load at Risk during three stages of failure, and the typical duration of each stage:-

i) During fault (T1): this is the time period between initial circuit protection trip operation and automatic switching to reconfigure the network;

ii) During initial switching (T2): this is the time period during which further manual network switching is undertaken to reconfigure the network to minimise the risk associated with a further circuit outage; and

iii) During repair time (T3).

These three stages are illustrated in Figure 30.

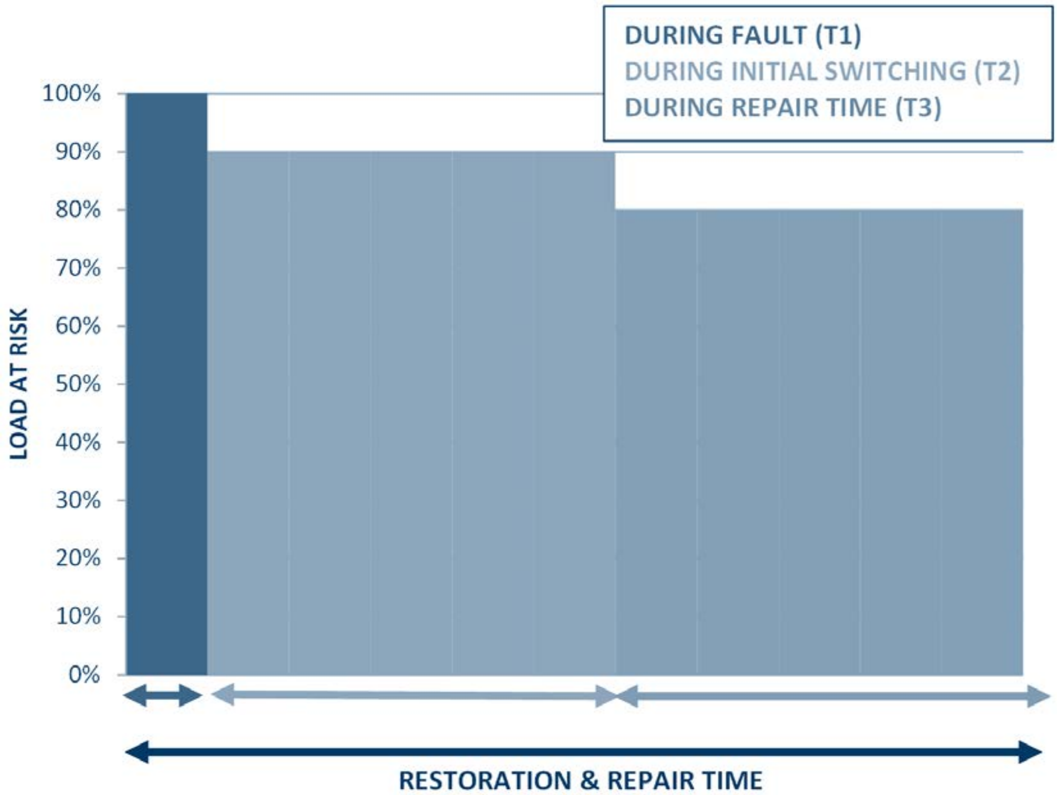

FIGURE 30: REFERENCE NETWORK PERFORMANCE COST OF FAILURE (EHV & 132KV)

The Load at Risk during each stage represents the amount of load that would experience a loss of supply if a further circuit outage were to occur. The probability of the occurrence of such a further coincident outage is considered in the derivation of the Reference Network Performance Cost Of Failure.

The proportion of failures that result in an unplanned outage is also considered. This is taken as being the proportion of total failures that are Degraded Failures or Catastrophic Failures. It is assumed that remedial works to address Incipient Failures can be undertaken as planned works and therefore can be scheduled, or mitigation measures employed, to avoid any Network Performance impact of a coincident outage.

The Load at risk, duration, probability of a further coincident outage and proportion of failures resulting in an unplanned outage are used to derive the probable amount of load lost (in MVAh) per failure. The relevant Value of Lost Load (VoLL) is then used to derive a typical Reference Network Performance Cost of Failure for these assets.

$$\begin{aligned}&\textbf{Reference Network Performance Cost of Failure} = \\&\big((\textbf{Load at risk in T1} \times \textbf{Duration of T1}) + (\textbf{Load at risk in T2} \times \textbf{Duration of T2}) + \\&(\textbf{Load at risk in T3} \times \textbf{Duration of T3})\big) \times \textbf{\% of failures that result in an unplanned outage} \times \\&\textbf{Probability of further coincident outage} \times \textbf{VoLL}\end{aligned} \quad \text{(Eq. 38)}$$

The value of VoLL adopted in this instance is £18,143 (Para 4.11 of Ofgem’s document titled “Strategy decision for the RIIO-ED1 electricity distribution price control - Reliability and safety” quotes the link between the IIS CI and CML setting for RIIO-ED1 to the VoLL set in RIIO-T1, of £16,000. This has been inflated to 2012/13 prices).

Typical values of Load at Risk have been used, for each Asset Category in deriving the Reference Network Performance Cost Of Failure. These are based on consideration of:-

- typical values for the maximum demand that would normally be supplied from the affected section of network; and
- the proportion of the maximum demand that would be at risk of loss of supply, should a further coincident outage occur, during each stage (i.e. periods T1, T2 and T3)

such that:

$$\begin{aligned}\text{Load at risk in T1} &= \text{Maximum Demand} * \%\text{ of maximum demand at risk during T1};\\ \text{Load at risk in T2} &= \text{Maximum Demand} * \%\text{ of maximum demand at risk during T2};\\ \text{Load at risk in T3} &= \text{Maximum Demand} * \%\text{ of maximum demand at risk during T3}\end{aligned}$$ (Eq. 41)

In this way, the Reference Network Performance Cost of Failure represents costs associated with a given level of maximum demand. This is representative of networks that are secure for a first circuit outage.

For linear assets (Cables and OHL), the maximum demand that is used to derive the reference costs is determined by applying a likely utilisation to a typical circuit rating for circuits of that voltage.

For discrete plant assets, the load at risk is more quantifiable and therefore the maximum demand that is used to derive the reference costs is based on the rating of the asset (in the case of transformers) or the board at the substation in the case of switchgear (it is assumed half of the switchboard would be out of commission for the catastrophic failure of a circuit breaker).

Table 226 shows the values of Reference Network Performance Cost of Failure that shall be used for EHV and 132kV assets. This table also shows the maximum demand used to derive these reference costs. The Load Factor that is applied in the calculation of Network Performance Consequences shall be calculated using these maximum demand values.

TABLE 227: REFERENCE NETWORK PERFORMANCE COST OF FAILURE FOR EHV & 132KV ASSETS (SECURE)

Asset Category	Maximum Demand Used To Derive Reference Cost (MVA)	Load at Risk (MVA) as % of Maximum Demand			Time (hours)			Probability of a coincident fault per hr	Proportion of failures that result in an unplanned outage	Reference Cost For Assets In Secure Networks (£)
		During T1 period	During T2 period	During T3 period	T1	T2	T3			
33kV Pole	9	100%	100%	80%	0	3	5	0.050%	10%	£57
66kV Pole	18	100%	100%	80%	0	3	5	0.050%	10%	£114
33kV Tower	9	100%	100%	80%	0	3	24	1.000%	20%	£7,250
66kV Tower	18	100%	100%	80%	0	3	36	1.000%	20%	£20,770
132kV Tower	36	100%	100%	80%	0	3	36	1.000%	20%	£41,540
33kV Fittings	9	100%	100%	80%	0	3	9	0.050%	20%	£167
66kV Fittings	18	100%	100%	80%	0	3	9	0.050%	20%	£333
132kV Fittings	36	100%	100%	80%	0	3	9	0.050%	20%	£666
33kV OHL (Tower Line) Conductor	9	100%	100%	80%	0	3	9	0.050%	100%	£833
66kV OHL Conductor	18	100%	100%	80%	0	3	9	0.050%	100%	£1,666
132kV OHL (Tower Line) Conductor	36	100%	100%	80%	0	3	9	0.050%	100%	£3,331
33kV UG Cable (Non Pressurised)	10.5	100%	100%	80%	0	3	30	0.050%	100%	£2,572
33kV UG Cable (Oil)	10.5	100%	100%	80%	0	3	30	0.050%	0.1%	£3
33kV UG Cable (Gas)	10.5	100%	100%	80%	0	3	30	0.050%	1%	£26
66kV UG Cable (Non Pressurised)	21	100%	100%	80%	0	3	30	0.050%	100%	£5,144
66kV UG Cable (Oil)	21	100%	100%	80%	0	3	30	0.050%	0.1%	£5
66kV UG Cable (Gas)	21	100%	100%	80%	0	3	30	0.050%	1%	£51
132kV UG Cable (Non Pressurised)	42	100%	100%	80%	0	3	30	0.050%	100%	£10,287
132kV UG Cable (Oil)	42	100%	100%	80%	0	3	30	0.050%	0.1%	£10
132kV UG Cable (Gas)	42	100%	100%	80%	0	3	30	0.050%	1%	£103
EHV Sub Cable	10.5	100%	100%	80%	0	3	30	0.050%	100%	£2,572
132kV Sub Cable	42	100%	100%	80%	0	3	30	0.050%	100%	£10,287

Asset Category	Maximum Demand Used To Derive Reference Cost (MVA)	Load at Risk (MVA) as % of Maximum Demand			Time (hours)			Probability of a coincident fault per hr	Proportion of failures that result in an unplanned outage	Reference Cost For Assets In Secure Networks (£)
		During T1 period	During T2 period	During T3 period	T1	T2	T3			
33kV CB (Air Insulated Busbars)(ID) (GM)	30	100%	100%	80%	0	2	200	0.050%	55%	£24,248
33kV CB (Air Insulated Busbars)(OD) (GM)	30	100%	100%	80%	0	2	100	0.050%	55%	£12,274
33kV CB (Gas Insulated Busbars)(ID) (GM)	30	100%	100%	80%	0	2	200	0.050%	55%	£24,248
33kV CB (Gas Insulated Busbars)(OD) (GM)	30	100%	100%	80%	0	2	100	0.050%	55%	£12,274
33kV Switch (GM)	30	100%	100%	80%	0	2	100	0.050%	55%	£12,274
33kV RMU	30	100%	100%	80%	0	2	100	0.050%	55%	£12,274
66kV CB (Air Insulated Busbars)(ID) (GM)	30	100%	100%	80%	0	2	200	0.050%	55%	£24,248
66kV CB (Air Insulated Busbars)(OD) (GM)	30	100%	100%	80%	0	2	100	0.050%	55%	£12,274
66kV CB (Gas Insulated Busbars)(ID) (GM)	30	100%	100%	80%	0	2	200	0.050%	55%	£24,248
66kV CB (Gas Insulated Busbars)(OD) (GM)	30	100%	100%	80%	0	2	100	0.050%	55%	£12,274
132kV CB (Air Insulated Busbars)(ID) (GM)	80	100%	100%	80%	0	1	400	0.050%	55%	£128,126
132kV CB (Air Insulated Busbars)(OD) (GM)	80	100%	100%	80%	0	1	100	0.050%	55%	£32,331
132kV CB (Gas Insulated Busbars)(ID) (GM)	80	100%	100%	80%	0	1	400	0.050%	55%	£128,126
132kV CB (Gas Insulated Busbars)(OD) (GM)	80	100%	100%	80%	0	1	100	0.050%	55%	£32,331
33kV Transformer (GM)	30	100%	100%	80%	0	2	400	0.050%	55%	£48,197
66kV Transformer	30	100%	100%	80%	0	2	400	0.050%	55%	£48,197
132kV Transformer	80	100%	100%	80%	0	1	800	0.050%	55%	£255,853

D.4.4 Network Performance Factors (EHV & 132kV)

As described in Section 7.6.3.2 the Network Performance CoF is derived on an asset by asset basis as shown in Eq. 39.

$$\text{Network Performance Consequences of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Load Factor} \times \text{Network Type Factor} \quad \text{(Eq. 39)}$$

Load Factor

This Factor allows for the Network Performance CoF to reflect the actual load at risk associated with the failure of the asset under consideration, relative to the value of maximum demand used to create the reference value.

The Load Factor is determined as shown in Eq. 40 (i.e. not via a lookup table).

$$\text{Load Factor} = \frac{\text{Actual Load at Risk Associated with the Failure of the Asset Under Consideration}}{\text{Maximum Demand Used To Derive Reference Network Performance Cost of Failure}} \quad \text{(Eq. 40)}$$

For example, if the Reference Network Performance Cost of Failure has been derived using a reference maximum demand of 12MVA, but for a specific asset the actual load at risk was 6MVA then a Load Factor of 0.5 would be applied.

The values of maximum demand used in derivation of the Reference Network Performance Cost of Failure can be found in Table 226 in Appendix D.

Where the actual load is not known, the default value for Load Factor is dependent on the security of supply of the associated network.

A default Load Factor of 0.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A default Load Factor of 1 shall apply to assets in secure networks or where the security of the network is unknown.

Network Type Factor

This Network Performance CoF is derived on an asset by asset basis by the application of a Network Type Factor to take account of the security of supply afforded by the topology of the network in which the individual asset is located.

A Network Type Factor of 2.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A Network Type Factor of 1 shall apply to assets in secure networks.

The default value for Network Type Factor is 1.

APPENDIX E
WORKED EXAMPLES

E.1 Probability of Failure (PoF)

The described methodology is capable of representing a very wide range of asset conditions and situations. In order to provide the reader with some clarity, this section works through a selection of typical scenarios with references to the relevant section of the methodology. The examples begin with the simplest scenario first. In order to avoid repetition, each subsequent example will focus on the key differences with the previous examples. The scenarios presented here are not exhaustive, but provide an illustration of how the methodology works.

Example 1: A new LV pole with no associated condition information

The asset used in this example is a one-year-old steel LV pole, 5km from the coast, at an altitude of 100m, in corrosion zone 3. No condition information is available for this asset. For this asset, the following calculation steps enable the PoF (and associated Heath Index Band) to be determined:

<u>Normal Expected Life (see Section 6.1.3)</u>

1. The Normal Expected Life of a steel pole is given by Table 20 “Normal Expected Life” as **50** years

<u>Expected Life (see Section 6.1.4)</u>

2. The Distance From Coast Factor is given by Table 22 “Distance From Coast Factor Lookup Table” as **1.2**
3. The Altitude Factor is given by Table 23 “Altitude Factor Lookup Table” as **1**
4. The Corrosion Category Factor is given by Table 24 “Corrosion Category Factor Lookup Table” as **1**
5. The Location Factor is determined in accordance with Equation 11 as

$$\text{Location Factor} = \text{MAX}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor}) + \left(\left((\text{COUNT of factors greater than 1}) - 1\right) \times \text{INC}\right)$$

giving **MAX (1.2, 1, 1) + 0 = 1.2**

6. The Duty Factor is given by Table 8 “Duty Factor Methodology” as **1**
7. The Expected Life is given by Equation 2 as

$$\text{Expected Life} = \frac{\text{Normal Expected Life}}{(\text{Duty Factor} \times \text{Location Factor})}$$

giving **50 / (1.2 x 1) = 41.67** years

<u>β1 Initial Ageing Rate (see Section 6.15)</u>

8. The Initial Ageing Rate is given by Equation 3 as

$$\beta_1 = \frac{\ln\left(\frac{H_{\text{expected life}}}{H_{\text{new}}}\right)}{\text{Expected Life}}$$

giving **ln(5.5 / 0.5) / 41.67 = 0.05755**

Initial Health Score (see Section 6.1.6)

9. The Initial Health Score is given by Equation 4 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times age)}$$

giving **0.5 x e^(0.05755 x 1) = 0.53**

Current Health Score (see Section 6.1.7)

10. The Observed Condition Modifiers are given by Tables 95 to 98. As no condition information is available, the default values apply, namely Condition Input Factor = **1**, Condition Input Cap = **10**, Condition Input Collar = **0.5**
11. The Measured Condition Modifier is given by Table 185 “Measured Condition Input - LV Pole: Pole Decay / Deterioration”. As no condition information is available, the default values apply, namely Condition Input Factor = **1**, Condition Input Cap = **10**, Condition Input Collar = **0.5**
12. The Health Score Modifier is calculated using the MMI technique described in Section 6.7.2. In this case, all input factors are the same, resulting in a Health Score Modifier that consists of Health Score Factor = **1**, Health Score Cap = **10**, Health Score Collar = **0.5**
13. The Current Health Score is given by Equation 5 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **0.53 x 1 x 1 = 0.53**. The test conditions in Equations 6 and 7 confirm that this value is within the cap and collar range (0.5 to 10), so the Current Health Score is confirmed as **0.53**
14. The corresponding Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI1**

β_2 Forecast Ageing Rate (see Section 6.1.8)

15. The Forecast Ageing Rate is given by Equation 8 as

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}}$$

giving **ln(0.53 / 0.5) / 1 = 0.05827**
16. The test condition in Equation 9 confirms that this result for β_2 is within the cap of 2 x β_1

Ageing Reduction Factor (see Section 6.1.9)

17. The Current Health Score is less than 2, so Table 209 “Ageing Reduction Factor” confirms that the Ageing Reduction Factor is **1**

Future Health Score – Deterioration (see Section 6.1.10)

18. The Future Health Score is given by Equation 10

$$\text{Future Health Score} = \text{Current Health Score} \times e^{((\beta_2/r) \times t)}$$

For an eight-year forecast period, t is equal to **8**, so the Future Health Score is therefore **0.53 x e^((0.05827 / 1) x 8)) = 0.84**

19. The future Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI1**
20. The value of K is given by Table 21 “PoF Curve Parameters” as **0.00029**
21. The Current Health Score is <=4, so the PoF if given by setting H=4 in Equation 1

$$\text{PoF} = \text{K} \times \left[1 + (\text{C} \times \text{H}) + \frac{(\text{C} \times \text{H})^2}{2!} + \frac{(\text{C} \times \text{H})^3}{3!}\right]$$

This gives a PoF value of **0.00029 x (1 + (1.087 x 4) + (1.087 x 4)^2 / 2 + (1.087 x 4)^3 / 6) = 0.0081**

22. The Future Health Score is <=4, so the future PoF is again given by Equation 1 as **0.00029 x (1 + (1.087 x 4) + (1.087 x 4)^2 / 2 + (1.087 x 4)^3 / 6) = 0.0081**

In summary, this asset would be banded into the most reliable Health Index Band (HI1) and would remain there for the 8-year period under review.

Example 2: An ageing LV pole

The asset used in this example is a 50-year-old steel LV pole in the same location as the previous example i.e. located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. No condition information is available for this asset.

Steps 1 to 8 are exactly the same as in the previous example.

Initial Health Score (see Section 6.1.6)

9. The Initial Health Score is given by Equation 4 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times \text{age})}$$

giving **0.5 x e^(0.05755 x 50) = 8.88.** However, the result is capped to the maximum permissible value of **5.5**

Current Health Score (see Section 6.1.7)

Steps 10 to 12 are exactly the same as in the previous example.

13. The Current Health Score is given by Equation 5 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **5.5 x 1 x 1 = 5.5**. The test conditions in Equations 6 and 7 confirm that this value is within the cap and collar range (0.5 to 10), so the Current Health Score is confirmed as **5.5**

14. The corresponding Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI3**

β_2 Forecast Ageing Rate (see Section 6.1.8)

15. The Forecast Ageing Rate is given by Equation 8 as

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}}$$

giving **ln(5.5 / 0.5) / 50 = 0.04796**

16. The test condition in Equation 9 confirms that this result for β_2 is within the cap of 2 x β_1

Ageing Reduction Factor (see Section 6.1.9)

17. The Current Health Score is 5.5, so Table 209 “Ageing Reduction Factor” increases the Ageing Reduction Factor to **1.5**

Future Health Score – Deterioration (see Section 6.1.10)

18. The Future Health Score is given by Equation 10

$$\text{Future Health Score} = \text{Current Health Score} \times e^{((\beta_2/r) \times t)}$$

For an eight-year forecast period, t is equal to **8**, so the Future Health Score is therefore **5.5 x e^((0.04796 / 1.5) x 8)) = 7.10**

19. The future Health Index Band is given by Table 5 "Health Index Banding Criteria" as **HI4**
20. The value of K is given by Table 21 "PoF Curve Parameters" as **0.00029**
21. The Current Health Score is >4, so the current PoF from Equation 1 where H = Health Score

$$\text{PoF} = \text{K} \times \left[1 + (\text{C} \times \text{H}) + \frac{(\text{C} \times \text{H})^2}{2!} + \frac{(\text{C} \times \text{H})^3}{3!}\right]$$

is **0.00029 x (1 + (1.087 x 5.5) + (1.087 x 5.5)^2 / 2 + (1.087 x 5.5)^3 / 6) = 0.017** – approximately twice that of the new pole in the first example

22. Future Health Score is >4, so the future PoF is similarly given by Equation 1 as **0.00029 x (1 + (1.087 x 7.1) + (1.087 x 7.1)^2 / 2 + (1.087 x 7.1)^3 / 6) = 0.033** – approximately four times that of the new pole in the first example

In summary, this asset would be banded into the middle Health Index Band (HI3) and would progress to the next band (HI4) by the end of the 8-year period under review, when it would be approximately four times more likely to fail than a new pole.

Example 3: A mid-life LV pole with evidence of degraded condition

The asset used in this example is a 25-year-old steel LV pole in the same location as the previous example i.e. located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. The pole has been inspected and was found to have significant loss of residual strength, although within an acceptable level.

Steps 1 to 8 are exactly the same as in the previous example.

Initial Health Score (see Section 6.1.6)

9. The Initial Health Score is given by Equation 4 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times \text{age})}$$

giving **0.5 x e^(0.05755 x 25) = 2.11**

Current Health Score (see Section 6.1.7)

Step 10 is the same as in the previous example.

11. The Measured Condition Modifier is given by Table 185 “Measured Condition Input - LV Pole: Pole Decay / Deterioration”. The pole has significant loss of residual strength, although within an acceptable level and so would be classified as having “High” deterioration. Therefore Condition Input Factor =**1.4**, Condition Input Cap = **10**, Condition Input Collar = **5.5**
12. The Health Score Modifier is calculated using the MMI technique described in Section 6.7.2. In this case, the result is driven by the highest Condition Input Factor, resulting in a Health Score Modifier that consists of Health Score Factor = **1.4**, Health Score Cap = **10**, Health Score Collar = **5.5**
13. The Current Health Score is given by Equation 5 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **2.11 x 1.4 x 1 = 2.95**. However, the test conditions in Equations 6 and 7 show that this is outside the cap and collar range (5.5 to 10), so the Current Health Score is collared to **5.5**

14. The corresponding Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI3**

β_2 Forecast Ageing Rate (see Section 6.1.8)

15. The Forecast Ageing Rate is given by Equation 8 as

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}}$$

giving **ln(5.5 / 0.5) / 25 = 0.09591**.

16. The test condition in Equation 9 confirms that this result for β_2 is within the cap of 2 x β_1

Ageing Reduction Factor (see Section 6.1.9)

17. The Current Health Score is 5.5, so Table 209 “Ageing Reduction Factor” increases the Ageing Reduction Factor to **1.5**

Future Health Score – Deterioration (see Section 6.1.10)

18. The Future Health Score is given by Equation 10

$$\textbf{Future Health Score} = \textbf{Current Health Score} \times e^{((\beta_2/r)\times t)}$$

For an eight-year forecast period, t is equal to **8**, so the Future Health Score is therefore **5.5 x e^((0.09591 / 1.5) x 8)) = 9.17**

19. The future Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI5**
20. The value of K is given by Table 21 “PoF Curve Parameters” as **0.00029**
21. The Current Health Score is >4, so the current PoF from Equation 1 where H = Health Score

$$PoF = K \times \left[1 + (C \times H) + \frac{(C \times H)^2}{2!} + \frac{(C \times H)^3}{3!}\right]$$

is **0.00029 x (1 + (1.087 x 5.5) + (1.087 x 5.5)^2 / 2 + (1.087 x 5.5)^3 / 6) = 0.017** - approximately twice that of the new pole in the first example

22. Future Health Score is >4, so the future PoF is similarly given by Equation 1 as **0.00029 x (1 + (1.087 x 9.17) + (1.087 x 9.17)^2 / 2 + (1.087 x 9.17)^3 / 6) = 0.064** – approximately eight times that of the new pole in the first example

In summary, this asset would be banded into the middle Health Index Band (HI3) and would progress to the worst band (HI5) by the end of the 8-year period under review, when it would be approximately eight times more likely to fail than a new pole.

Example 4: An EHV transformer in good condition

The asset used in this example is a 40-year-old 33kV transformer located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. It is 50% loaded and averages 5 taps per day. Condition information is available, showing that the main transformer tank has low levels of DGA. This example illustrates how the health scores of two asset sub-components are combined to give an overall health score.

<u>Normal Expected Life (see Section 6.1.3)</u>

1. The Normal Expected Life of a pre-1980 33kV transformer and tapchanger is given by Table 20 “Normal Expected Life” as **60** years

<u>Expected Life (see Section 6.1.4)</u>

2. The Distance From Coast Factor is given by Table 22 “Distance From Coast Factor Lookup Table” as **1.1**
3. The Altitude Factor is given by Table 23 “Altitude Factor Lookup Table” as **0.9**
4. The Corrosion Category Factor is given by Table 24 “Corrosion Category Factor Lookup Table” as **1**
5. The Location Factor is determined in accordance with Equation 11 as

$$\text{Location Factor} = \text{MAX}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor}) + \left(\left((\text{COUNT of factors greater than 1}) - 1\right) \times \text{INC}\right)$$

   giving **MAX (1.1, 0.9, 1) + 0 = 1.1**

6. The Transformer Duty Factor is given by Table 33 “Duty Factor Lookup Tables - Grid & Primary Transformers” as **1**
7. The Tapchanger Duty Factor is given by Table 33 “Duty Factor Lookup Tables - Grid & Primary Transformers” as **0.9**
8. The Transformer Expected Life is given by Equation 2 as

$$\text{Expected Life} = \frac{\text{Normal Expected Life}}{(\text{Duty Factor} \times \text{Location Factor})}$$

   giving **60 / (1.1 x 1) = 54.55** years

9. The Tapchanger Expected Life is given similarly by Equation 2 as **60 / (1.1 x 0.9) = 60.61** years

<u>β1 Initial Ageing Rate (see Section 6.15)</u>

10. The Transformer Initial Ageing Rate is given by Equation 3 as

$$\beta_1 = \frac{\ln\left(\frac{H_{\text{expected life}}}{H_{\text{new}}}\right)}{\text{Expected Life}}$$

   giving **ln(5.5 / 0.5) / 54.55 = 0.04396**

11. The Tapchanger Initial Ageing Rate is given similarly by Equation 3 as **ln(5.5 / 0.5) / 60.61 = 0.03957**

Initial Health Score (see Section 6.1.6)

12. The Transformer Initial Health Score is given by Equation 4 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times \text{age})}$$

giving **0.5 x e^(0.04396 x 40) = 2.90**

13. The Tapchanger Initial Health Score is given similarly by Equation 4 as **0.5 x e^(0.03957 x 40) = 2.43**

Current Health Score (see Section 6.1.7)

14. The Health Score Modifier is calculated using the MMI technique described in Section 6.8. In this case, all input factors are neutral, resulting in a Health Score Modifier that consists of Health Score Factor = **1**, Health Score Cap = **10**, Health Score Collar = **0.5** for both the Transformer and the Tapchanger
15. The Transformer Current Health Score is given by Equation 5 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **2.90 x 1 = 2.90**. The test conditions in Equations 6 and 7 confirm that this value is within the cap and collar range (0.5 to 10), so the Transformer Current Health Score is confirmed as **2.90**

16. The Tapchanger Current Health Score is similarly given by Equation 5 as **2.43 x 1 = 2.43** Equations 6 and 7 confirm that this value is within the cap and collar range (0.5 to 10), so the Tapchanger Current Health Score is confirmed as **2.43**
17. The combined Current Health Score is derived according to Section 6.2 as **MAX(2.90, 2.43) = 2.90**
18. The corresponding Health Index Band is given by Table 5 as **HI1**

The derivation of the PoF and Future Health Score then follows the same pattern as described in Steps 15 to 22 in the first example. In this case, the transformer will remain in Health Index Band HI1 through to the end of the 8-year period under review.

Example 5: An EHV transformer with rising DGA levels

The asset used in this example the same 40-year-old 33kV transformer located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. It is 50% loaded and averages 5 taps per day. Additional condition information is available, showing that the DGA in the main transformer has risen from 10ppm (Hydrogen, Methane, Ethylene, Ethane) and 5ppm (Acetylene) to 50ppm (Hydrogen), 25ppm (Methane, Ethylene, Ethane) and 10ppm (Acetylene). In addition, Oil Moisture is measured at 15ppm, Acidity at 0.2 mg KOH/g and oil breakdown at 25kV. This is indicative of degradation and accelerated ageing, placing the transformer at increased risk of failure.

This example illustrates how the poor condition of a sub-component affects the overall health score.

Steps 1 to 13 are exactly the same as in the previous example.

Current Health Score (see Section 6.1.7)

14. The Health Score Modifier is calculated using the MMI technique described in Section 6.8. In this case, the DGA test results in a Health Score Modifier that consists of Health Score Factor = **1.5**, Health Score Cap = **10**, Health Score Collar = **4.73** for the Transformer and Health Score Factor = **1**, Health Score Cap = **10**, Health Score Collar = **0.5** for the Tapchanger
15. The Transformer Current Health Score is given by Equation 5 as

$$\textbf{Current Health Score} = \textbf{Initial Health Score} \times \textbf{Health Score Factor} \times \textbf{Reliability Factor}$$

giving **2.90 x 1.9 = 5.51**. The test conditions in Equations 6 and 7 confirm that this value is within the cap and collar range (4.73 to 10), so the Transformer Current Health Score is confirmed as **5.51**

16. The Tapchanger Current Health Score is similarly given by Equation 5 as **2.43 x 1 = 2.43**. Equations 6 and 7 confirm that this value is within the cap and collar range (0.5 to 10), so the Tapchanger Current Health Score is confirmed as **2.43**
17. The combined Current Health Score is derived according to Section 6.2 as **MAX(5.51, 2.43) = 5.51**
18. The corresponding Health Index Band is given by Table 5 as **HI3**

The derivation of the PoF and Future Health Score then follows the same pattern as described in Steps 15-22 in the first example. In this case, the transformer will reach Health Index Band HI4 by the end of the 8-year period under review.

E.2 Consequences of Failure

The described methodology is capable of representing a very wide range of asset criticalities. In order to provide the reader with some clarity, this section works through a selection of typical scenarios. The scenarios presented here are not exhaustive, but provide an illustration of how the methodology works.

Example 1: A distribution RMU with a typical number of connected customers

The asset used in this example is an 11kV oil-filled RMU supplying 800 customers with normal access arrangements. The safety location and type risks have been assessed as “Medium” in accordance with ESQCR. It is moderately close to a water course. For this asset, the following calculation steps enable the Consequences of Failure to be determined:

Financial Consequences (see Section 7.3)

1. Table 16 “Reference Costs of Failure” gives the Reference Financial Cost of Failure as **£8,190**
2. Table 214 “Access Factor: Switchgear & Transformer Assets” gives the Access Factor as **1**
3. Applying Equations 26 and 27

$$\text{Financial Consequences of Failure} = \text{Reference Financial Cost of Failure} \times \text{Financial Consequences Factor}$$

$$\text{Financial Consequences Factor} = \text{Type Financial Factor} \times \text{Access Financial Factor}$$

gives the Financial Consequences of Failure as **£8,190 x 1 = £8,190**

Safety Consequences (see Section 7.4)

4. Table 16 “Reference Costs of Failure” gives the Reference Safety Cost of Failure as **£4,262**
5. Table 218 “Safety Consequence Factor – Switchgear, Transformers & Overhead Lines” gives the Safety Consequence Factor as **1**
6. Applying Equation 29

$$\text{Safety Consequences of Failure} = \text{Reference Safety Cost of Failure} \times \text{Safety Consequences Factor}$$

gives the Safety Consequences of Failure as **£4,262 x 1 = £4,262**

Environmental Consequences (see Section 7.5)

7. Table 16 “Reference Costs of Failure” gives the Reference Environmental Cost of Failure as **£1,108**
8. Table 221 “Type Environmental Factor” gives the Type Environmental Factor as **0.97**
9. Table 223 “Location Environmental Factor” gives a Proximity Factor of **1** and a Bunding Factor of **1**. The Location Environmental Factor is therefore equal to **1**

10. Applying Equations 31 and 32

$$\text{Environmental Consequences of Failure} = \text{Reference Environmental Cost of Failure} \times \text{Environmental Consequences Factor}$$

$$\text{Environmental Consequences Factor} = \text{Type Environmental Factor} \times \text{Size Environmental Factor} \times \text{Location Environmental Factor}$$

gives the Environmental Consequences of Failure as **£1,108 x 0.97 = £1,075**

Network Performance Consequences (see Section 7.6)

11. Table 16 "Reference Costs of Failure" gives the Reference Network Performance Cost of Failure as **£7,780**
12. Applying Equations 36 and 37

$$\text{Network Performance Consequence Factor} = \text{Customer Factor} \times \text{Customer Sensitivity Factor}$$

$$\text{Customer Factor} = \frac{\text{No. of Customers}}{\text{Reference No. of Customers}}$$

gives the Network Performance Consequence Factor as **800 / 800 x 1 = 1**

13. Applying Equation 35

$$\text{Network Performance Cost of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Network Performance Consequence Factor}$$

gives the Network Performance Cost of Failure as **£7,780 x 1 = £7,780**

Consequences of Failure (see Section 7.1)

14. Figure 21 "Consequences of Failure" shows that the total Consequences of Failure is the sum of the above, giving **£8,190 + £4,262 + £1,075 + £7,780 = £21,307**

The classification of Consequences of Failure into Criticality Bands C1, C2, C3 and C4 is a function of the Average Overall Consequences of Failure for the Asset Category, as shown in Table 7 "Criticality Index Banding Criteria".

Example 2: A distribution RMU with a single commercial customer

The asset used in this example is an 11kV oil-filled RMU supplying a single commercial customer 600kVA of load and normal access arrangements. The safety location is assessed as having few hazards, but has evidence of interference and the Safety Type as indoor but less secure. It is not close to a water course. For this asset, the following calculation steps enable the Consequences of Failure to be determined:

Steps 1 to 10 are exactly the same as in the previous example.

Network Performance Consequences (See Section 7.6)

11. Applying Table 18 “Customer Number Adjustment for LV & HV Assets with High Demand Customers” gives the multiplier on the number of customers as **250**
12. Applying Equations 36 and 37

$$\text{Network Performance Consequence Factor} = \text{Customer Factor} \times \text{Customer Sensitivity Factor}$$

$$\text{Customer Factor} = \frac{\text{No. of Customers}}{\text{Reference No. of Customers}}$$

gives the Network Performance Consequence Factor as **250/800 x 1 = 0.31**

13. Applying Equation 35

$$\text{Network Performance Cost of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Network Performance Consequence Factor}$$

gives the Network Performance Cost of Failure as **£7,780 x 0.31 = £2,431**

Consequences of Failure (see Section 7.1)

14. Figure 21 “Consequences of Failure” shows that the total Consequences of Failure is the sum of the above, giving **£8,190 + £4,262 + £1,075 + £2,431 = £15,958**

The classification of Consequences of Failure into Criticality Bands C1, C2, C3 and C4 is a function of the Average Overall Consequences of Failure for the Asset Category, as shown in Table 7 “Criticality Index Banding Criteria”.

Example 3: An EHV transformer with typical loading

The asset used in this example is a 33/11kV, 24MVA-rated transformer with normal access arrangements. The safety location has not been assessed. It is bunded and moderately close to a water course. It has a maximum demand of 10MVA and is in an "n-1" (or Secure) configuration. For this asset, the following calculation steps enable the Consequences of Failure to be determined:

Financial Consequences (see Section 7.3)

1. Table 16 "Reference Costs of Failure" gives the Reference Financial Cost of Failure as **£73,000**
2. Table 212 "Type Financial Factors" gives the Type Financial Factor as **1.1**
3. Table 214 "Access Factor: Switchgear & Transformer Assets" gives the Access Factor as **1**
4. Applying Equations 26 and 27

$$\text{Financial Consequences of Failure} = \text{Reference Financial Cost of Failure} \times \text{Financial Consequences Factor}$$

$$\text{Financial Consequences Factor} = \text{Type Financial Factor} \times \text{Access Financial Factor}$$

gives the Financial Consequences of Failure as **£73,000 x 1.1 x 1 = £80,300**

Safety Consequences (see Section 7.4)

5. Table 16 "Reference Costs of Failure" gives the Reference Safety Cost of Failure as **£20,771**
6. Table 218 "Safety Consequence Factor – Switchgear, Transformers & Overhead Lines" gives the Safety Consequence Factor as **1**
7. Applying Equation 29

$$\text{Safety Consequences of Failure} = \text{Reference Safety Cost of Failure} \times \text{Safety Consequences Factor}$$

gives the Safety Consequences of Failure as **£20,771x 1 = £20,771**

Environmental Consequences (see Section 7.5)

8. Table 16 "Reference Costs of Failure" gives the Reference Environmental Cost of Failure as **£14,190**
9. Table 221 "Type Environmental Factor" gives the Type Environmental Factor as **1**
10. Table 222 "Size Environmental Factor" gives the Size Environmental Factor as **1.6**
11. Table 223 "Location Environmental Factor" gives a Proximity Factor of **1** and a Bunding Factor as **0.5**. The Location Environmental Factor is therefore equal to **1**
12. Applying Equations 31 to 33

$$\text{Environmental Consequences of Failure} = \text{Reference Environmental Cost of Failure} \times \text{Environmental Consequences Factor}$$

$$\text{Environmental Consequences Factor} = \text{Type Environmental Factor} \times \text{Size Environmental Factor} \times \text{Location Environmental Factor}$$

$$\text{Location Environment Factor} = \text{Proximity Factor} \times \text{Bunding Factor}$$

gives the Environmental Consequences of Failure as **£14,190 x 1 x 1.6 x 0.5 = £11,352**

<u>Network Performance Consequences (see Section 7.6)</u>

13. Table 16 “Reference Costs of Failure” gives the Reference Network Performance Cost of Failure as **£48,197**
14. Applying Equation 40

$$\text{Load Factor} = \frac{\text{Actual Load Supplied By Asset}}{\text{Maximum Demand Used To Derive Reference Network Performance Cost of Failure}}$$

gives the Load Factor as **10 / 30 = 0.33**

15. Applying Equation 39

$$\text{Network Performance Consequences of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Load Factor} \times \text{Network Type Factor}$$

gives the Network Performance Consequence of Failure as **£48,197 x 0.33 x 1 = £16,066**

<u>Consequences of Failure (see Section 7.1)</u>

16. Figure 21 “Consequences of Failure” shows that the total Consequences of Failure is the sum of the above, giving **£80,300 + £20,771 + £11,352 + £16,066 = £128,489**

The classification of Consequences of Failure into Criticality Bands C1, C2, C3 and C4 is a function of the Average Overall Consequences of Failure for the Asset Category, as shown in Table 7 “Criticality Index Banding Criteria”.