AMS – Victoria Electricity Transmission Network

Fire Detection and Suppression

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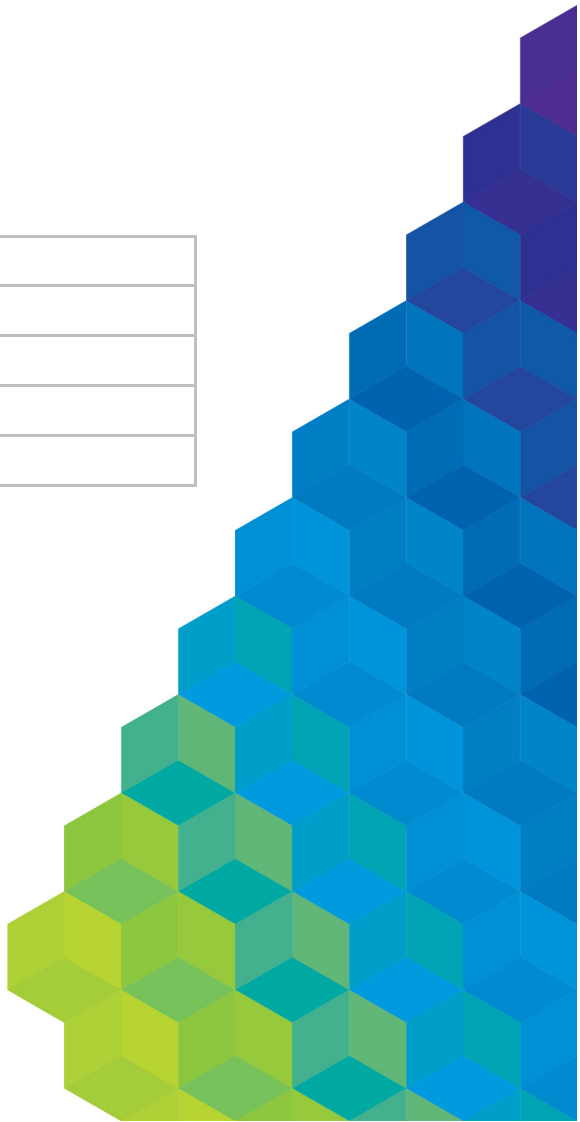

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Disclaimer

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1 Executive Summary

This document describes the asset management strategies for Fire Protection System (FPS) and Fire Suppression System (FSS) assets located at terminal stations in the Victorian electricity transmission network.

Terminal station buildings and switchyards are equipped with a combination of FPSs and FSSs, such as:

- Very Early Smoke Detection and Alarm (VESDA) Fire Detection Systems (FDTS);
- Multi zoned Smoke detectors and Fire Indicator Board (FIB);
- Portable Fire Extinguisher (PFE);
- Fire rated doors and walls between zones;
- Fire pillows;
- Fire walls;
- Water Deluge System (WDS); and
- Fire Hydrant System (FHS).

The FPS and FSS assets are in place to mitigate the effects of potentially destructive fires. A fire in a terminal station can cause extensive damage to critical assets in the electricity supply chain which can take time to replace thereby causing long supply disruptions resulting in huge disruption to the community. Fire at terminal stations also has potential to spread, which poses a high risk for properties etc. in surrounding areas. Hence detection of fire and initiation of fire suppression as early as possible is the key to minimising fire related risks in terminal stations.

Condition assessments at terminal stations indicate that 53% of FHS assets and 60% of WDS assets are in poor or very poor condition and are likely to require replacement/ refurbishment within the next ten years. Upgrade programs and replacement projects have been initiated for the affected terminal stations and are expected to be complete by 2022.

The following summarises the fire detection and suppression asset management strategies:

- Continue regular inspection and tests for all FPSs in accordance with the relevant Australian Standards (AS1851).
- Ensure completion of the fire risk study proposed to assess the effectiveness of [C.I.C].
- Progressively replace all the remaining FHSs in C4 and C5 conditions with systems complying with relevant Australian Standards by the end of 2022.
- Refurbish / replace WDSs that are in C4 and C5 conditions.
- Retrofit adequate fire protection measures for spare transformers at HWTS and SMTS.
- Replace failing smoke detectors and FIPs in Control Buildings.

2 Introduction

2.1 Purpose

The purpose of this document is to define the asset management strategies for the Fire Protection Systems (FPS) and Fire Suppression Systems (FSS) associated with AusNet Services' electricity transmission network in Victoria.

2.2 Scope

This asset management strategy applies to all FPSs and FSSs in buildings and plant located in switchyards associated with AusNet Services' electricity transmission network in Victoria.

2.3 Objectives

The objectives of this asset management strategy are to:

- present an overview of the FPS and FSS assets and their respective age / condition profiles;
- manage business and network risks presented by fire, efficiently and to within acceptable limits;
- ensure the effective and consistent management of FPSs and FSSs throughout their life-cycle; and
- demonstrate that FPSs and FSSs are being managed prudently and economically throughout their life-cycle.

2.4 Abbreviations and Definitions

Abbreviation	Definition
FDTS	Fire Detection System
WDS	Water Deluge System
FHS	Fire Hydrant System
FIP/B	Fire Indicator Panel / Board
FPS	Fire Protection System
FSS	Fire Suppression System
PFE	Portable Fire Extinguisher
VESDA	Very Early Smoke Detection and Alarm

2.5 References

This asset management strategy forms part of a suite of documentation that supports the management of AusNet Services' assets, which include the following:

AMS 01-01	Asset Management System – Overview
AMS 10-01	Asset Management Strategy – Transmission Network
AMS 10-19	Plant and Equipment Maintenance
AMS 10-140	Fire Protection for Power Transformers and Oil Filled Reactors
AMS 10-142	Fire Hydrant Systems for Terminal Stations

3 Asset Summary

Fire detection and suppression systems are required to minimise service disruption and asset damage in case of fire. Terminal stations in the Victorian electricity transmission network are provided with different kinds of FPSs and FSSs which are listed below:

In Buildings:

- Very Early Smoke Detection and Alarm (VESDA) Fire Detection Systems (FDTS);
- Multi zoned Smoke detectors and Fire Indicator Board (FIB);
- Portable Fire Extinguisher (PFE);
- [C.I.C] Gas FSS in three critical terminal stations;
- Fire rated doors and walls between zones;
- Fire pillows / fire walls used to seal-up all secondary cable entry points to critical buildings within terminal stations.

In the Switchyard and Transformers:

- Water Deluge System (WDS);
- Fire Hydrant System (FHS) for buildings and transformers;
- Fire Walls.

All terminal stations have VESDA systems which are very sensitive systems used to detect smoke as early as possible. Usually a large number of detectors are used in different fire zones which are connected to a multi zone Fire Indicator Panel / Board (FIP/B) providing alarm to the Transmission Operations Centre and respective fire agencies.

FHSs are installed at strategic positions to provide water supply for fire-fighting agencies attending in response to a fire. The water supply for these hydrants comes via underground pipe work from external mains supply or on-site storage facilities such as dams and tanks. An example of a FHS is shown in Figure 1 below. Several stations have booster pumps installed to support weaker supply pressures.

PFEs are kept in all buildings for small fire suppressions.

[C.I.C] which are gaseous FSSs, have been installed at three critical stations (SMTS, ROTS and HWTS). These systems use a combination of inert gases (Nitrogen, Argon and Carbon dioxide) to extinguish the fire without damage to sensitive equipment. Release of these gases on fire reduces the oxygen level in room to 12.5% which quickly extinguishes the fire giving sufficient time for people to breathe and leave the room. An example of a gaseous FSS is shown below in Figure 2.

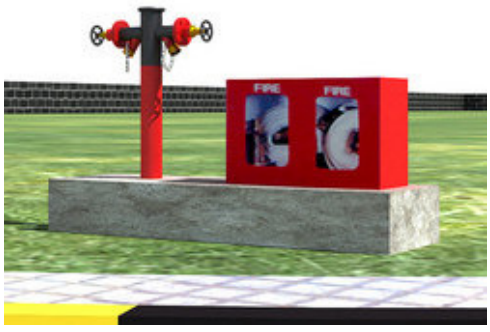

Figure 1 – Fire hydrant system

Figure 2 – Gaseous fire suppression system

In switchyards, fire walls and FHSs are installed to provide fire protection to power transformers and buildings (from outside). WDSs provide fire suppression for power transformers, when there is no other fire containment measure. Figure 3 illustrates an example of a WDS operating on a station transformer.

Other fire protection measures for power transformers include bund walls to contain oil spills, fire hydrants, and physical separation of transformers from other assets.

Figure 3 – Water deluge system operating on a power transformer

All systems are alarmed to the network control centre and in most cases the local MFB (Metropolitan Fire and Emergency Services Board) or CFA (Country Fire Authority).

3.1 Population

3.1.1 Buildings

VESDA (Very Early Smoke Detection Alarm) FDTSs are installed in all terminal station buildings that house critical protection, control and communications equipment. The control buildings are divided into fire zones and protected by smoke detectors linked to an FIB at the building entrance.

All buildings also have PFEs suitable for small electrical fires.

3.1.2 Switchyards

All terminal stations have Fire hydrant systems (FHSs) installed to suppress fire hazards[1] in switchyards and buildings (from outside). They are installed at strategic positions to provide water supply for firefighting agencies attending in response to a fire on buildings, transformers or any other major oil filled equipment.

Figure 4 shows the three types of pipe material that are used; UPVC, Asbestos Cement (AC) and Iron.

Figure 5 shows the type of pipe work and type of water supply to FHSs respectively in all the terminal stations.

[1] Station Design Manual – Volume 5, Section 15.

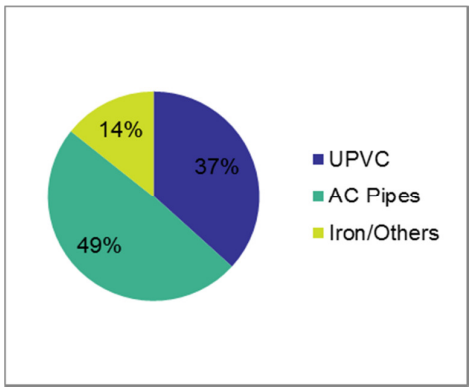

Figure 4 – Type of pipe work at terminal stations

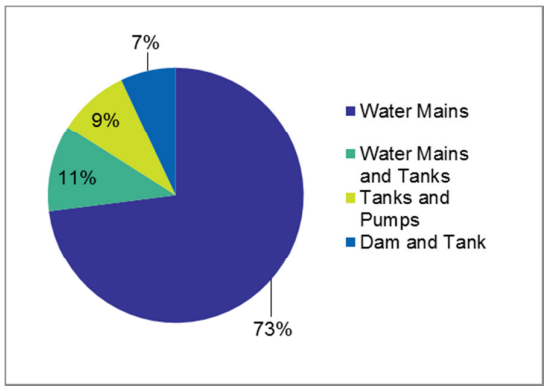

Figure 5 – Type of water supply at terminal stations

All power transformers installed in terminal stations have oil containment bund walls. A total of 39% have fire walls and 31% possess the required physical separation. A further 17% will have fire protection built during replacement of transformers in future projects.

Fire walls have mainly been installed in terminal stations located in the Melbourne metropolitan area.

Nine terminal stations have WDSs installed (13% of the power transformer population).

Table 1 below shows the number of WDSs installed in terminal stations.

Terminal Station	Number of Deluge systems
TSTS	2
ROTS	2
MLTS	3
HYTS	2
HWTS	4
BLTS	1
SMTS	3
KTS	3
FBTS	2
Total	**22**

Table 1 – Population of WDS assets

3.2 Age Profile

VESDA FDTSs were installed in all terminal stations between 2001 and 2005. Thermal and smoke detectors were also installed in parallel to VESDA FDTSs as independent systems in several locations. The useful life of detectors and FIB panels is expected to be 12 – 15 years.

The gaseous FSSs are approximately 10 years old.

FHSs and associated pipe work were installed when the stations were first established, with limited subsequent augmentation.

Figure 6 shows the age distribution of FHSs installed in all the terminal stations.

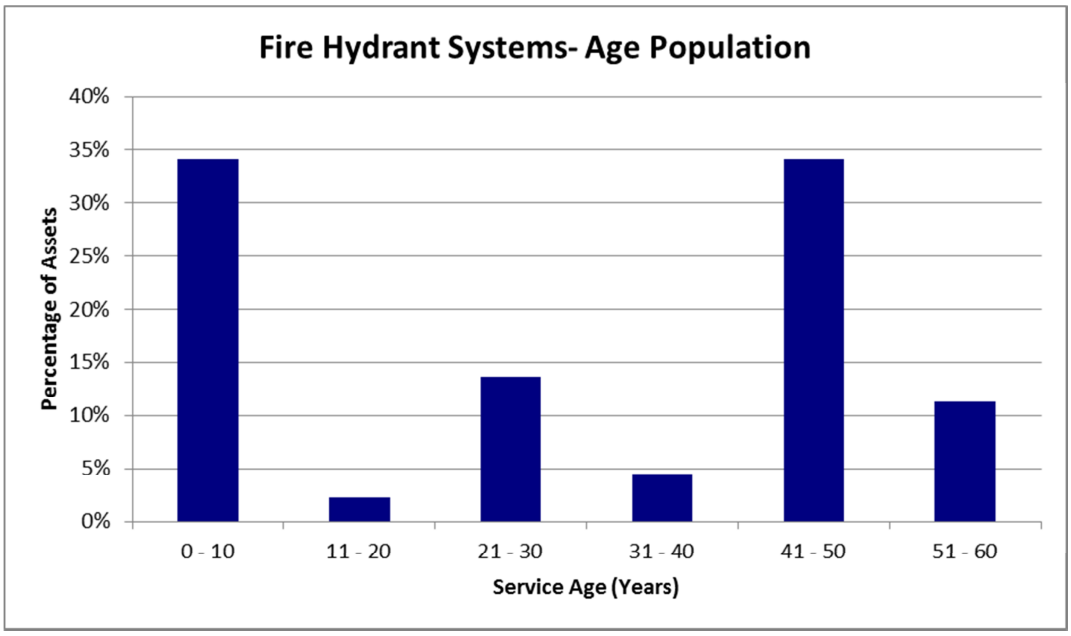

Figure 6 – Age distribution of FHS assets

WDS at terminal stations are the same age as the transformers they are protecting. Figure 7 shows the age distribution of WDSs installed in terminal stations.

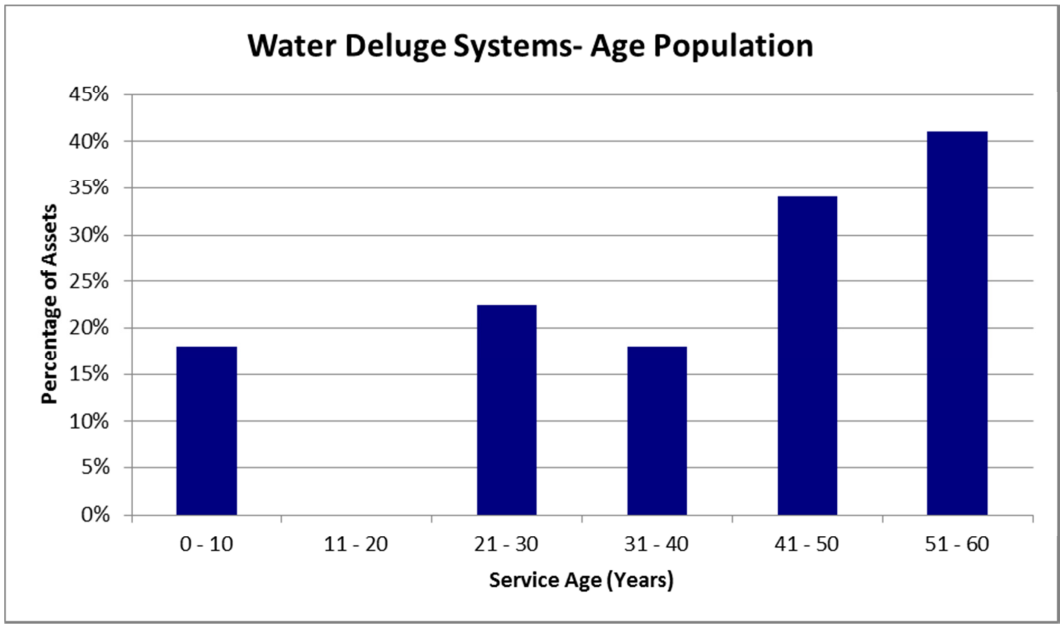

Figure 7 – Age distribution of WDS assets

3.3 Condition

The condition of FPS and FSS assets were assessed adhering to the criteria described in the Table 2 below. The following table provides definition of the various condition scores and recommendations.

Condition Score	Condition Description	Recommended Action
C1	Very good or original condition	No additional specific actions required, continue routine maintenance and condition monitoring.
C2	Better than average for age, Good condition	
C3	Average condition	
C4	Poor condition	Remedial action / replacement within 2 – 10 years.
C5	Very poor and approaching end of life	Remedial action / replacement within 1 – 5 years.

Table 2 – Condition score definition and recommended action

A condition score of C1 to C3 corresponds to an acceptable condition where no additional action (apart from continued routine maintenance and condition monitoring) is proposed. A condition score of C4 or C5 corresponds to assets with high to very high risk requiring remedial action in a relatively short defined timeframe.

Considering the importance of FPS assets in the control of fire related damage in terminal stations periodic inspections and operational checks are required. The maintenance activities are defined in AS 1851.1 and inspections and compliance checks are completed in accordance with this standard.

3.3.1 FDTS, PFE, FSS, FIB and [C.I.C]

All FDTSs, PFEs and FSSs are generally in good condition. Periodic maintenance and testing (every month) are carried out as per the relevant requirements of the Australian Standards for continued reliable operation. These systems are replaced when operational failure is detected in routine operational tests. The [C.I.C] FSS are also maintained in accordance to standard maintenance requirement in AS1851.1. Currently, these systems are due for the 10 yearly hydrostatic testing and recharge which requires the gas cylinders to be transported to the supplier's designated workshop.

Concerns have been raised about the effectiveness of these systems due to sealing requirements of the rooms. Buildings containing these systems are not tested for sealing capabilities and hence effectiveness of systems may be limited. Currently a fire risk study is proposed to be conducted to assess the fire risk and the effectiveness of these systems in present circumstances. Based on the outcome of this fire risk study a decision will be made regarding the continuation of these systems including their extension to other stations.

3.3.2 WDS

A large portion of the WDSs are in poor C4 and very poor C5 condition.

WDSs in Fisherman's Bend Terminal Station (FBTS), Brooklyn Terminal Station (BLTS) and Templestowe Terminal Station (TSTS) and Hazelwood Terminal Station (HWTS) were replaced in 2012.

WDSs at Heywood Terminal Station (HYTS), Keilor Terminal Station (KTS) and South Morang Terminal Station (SMTS) have corrosion issues and exhibit age related deterioration. The assets that are in very poor condition and are expected to be replaced in 2014 – 2018 under project XCB5. The remainder of the WDS assets are proposed to be replaced by the end of 2022.

Table 3 and Figure 8 below show the overall condition profile of WDS assets.

Station	WDS	Condition Rating	Remark
BLTS	1	2	Upgrade completed in 2012
FBTS	2	2	Upgrade completed in 2013
HWTS	4	3	Upgrade completed in 2015 through asset work
HYTS	2	5	
MLTS	3	4	
KTS	3	5	
ROTS	2	4	
SMTS	1	5	
TSTS	1	2	Upgrade completed in 2013

Table 3 – Overall condition rating of WDS assets at various terminal stations

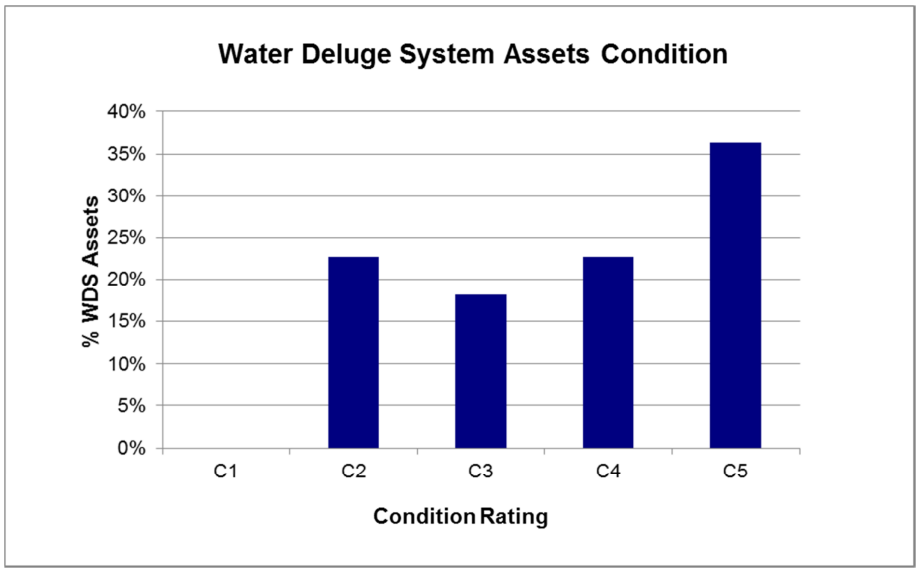

Figure 8 – Condition rating of WDS assets

3.3.3 FHS

Approximately 53% of FHSs are in condition C4 and C5. This is due to some sites having asbestos pipe works which are not compliant with AS 2419.1.

Refer to section 3.3.5 for information on FHS asset replacement/upgrade projects. Figure 9 below shows the condition of FHS assets.

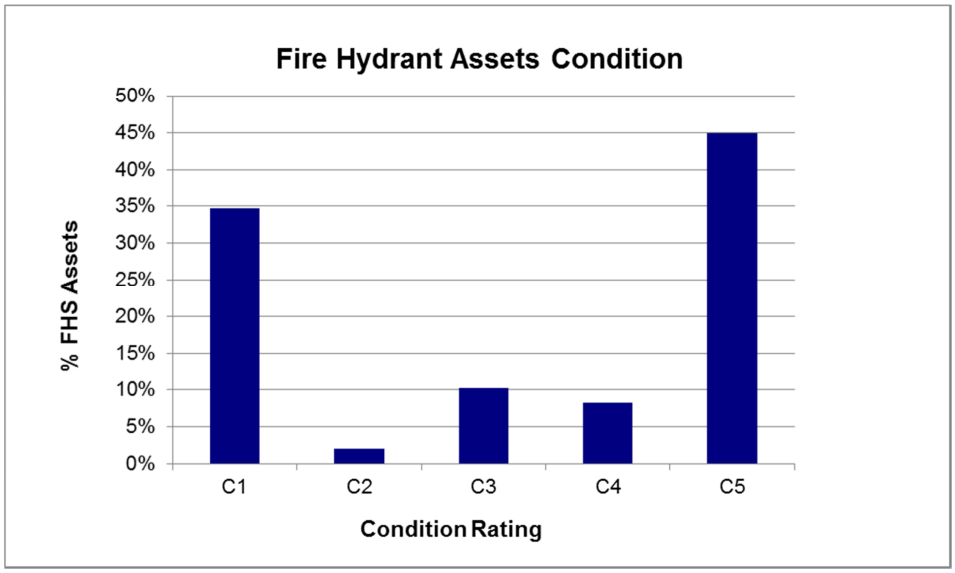

Figure 9 – Condition rating for FHS assets

3.3.4 Fire walls

Adequate fire walls are in place for in-service transformers in terminal stations located in the Melbourne metropolitan area and all are in good condition. Due to the recent inclusion of spare transformers at HWTS and SMTS, the installation of new firewalls is required at these sites which are covered in the planned work program for 2014 – 2019.

3.3.5 Project details

All the projects for the replacement / installation of FPS & FSS assets are listed below in Table 4.

Project Name and Site Covered	Project Number	Completion Year
FHS		
Facilities – hydrants fire suppression (DDTS, MLTS, SHTS)	X842	2012
Fire Hydrant Replacement in North (KGTS, SMTS and TTS)	XA35	2014
Fire Hydrants Replacements in Central (HOTS, TGTS, KTS)	XB35	2014
Fire protection – Fire hydrants replacement & upgrade – stage 3	XC34	March 2017
Upgrade of FHS assets under station rebuild works (RTS, BTS, HTS, WMTS)		2005-2022
Fire walls		
Installation of new firewalls at HWTS & SMTS	To be approved	
WDS		
Sync Con refurb – Fire Deluge System (FBTS, BLTS and TSTS)	XB46	2012
HWTS Upgrading of transformer fire deluge systems	VD30	2016
Upgrade / replacement of WDS at the due to corrosion and age related issues: HYTS, KTS & SMTS	Initiated (XCB5)	2015-2018
FIB		
20 Terminal stations with FIB in poor condition	Approved	2014-2022

Table 4 – FPS and FSS asset replacement project details

3.4 Performance Issues

3.4.1 FHS

AS 2419.1 (1994) specifies hydrostatic testing of FHS at 1700 kPa or 1.5 times the working pressure, whichever is greater. Some of the older pipe work and fittings (which were not designed to meet such pressure levels) have failed during testing and required replacement.

System bursts were observed during the tests at Horsham Terminal Station (HOTS), Moorabool Terminal Station (MLTS), Shepparton Terminal Station (SHTS) and Terang Terminal Station (TGTS).

Several FHS utilise asbestos pipes to supply the water for fire control and the condition of these pipes is uncertain. These pipes are not pressure tested due to fear of failure (high probability) during the high pressure test making reasonably accurate condition assessment very difficult. In the case of an AC pipe failure, the repair work could be delayed significantly due to work restrictions on any modification / repair works on assets containing asbestos cement material. Replacing these pipes is a major driver to renew the FHS at various terminal stations.

There have also been some issues regarding excessive pipeline pressure drop, insufficient flow rates, insufficient residual pressure and in some cases lack of booster connections for the CFA in shared pipe work with domestic pipes. These factors badly affect the performance of FSSs in the event of a fire hence; FHSs require good water pumps and other sources of water such as water storage tanks with sufficient storage capacity for water supply during fire incidents. Recent FHS renewal projects have found that 50% of terminal stations lack water supply pressure.

In some cases where transformer augmentation occurs and fire hydrant systems are extended, the local CFA/MFB do not grant fire compliance certificates and require the complete system to be upgraded, such as at Bendigo Terminal Station (BETS) in 2012.

3.4.2 Other FSSs

All the WDSs were installed when the transformers were installed. The insides of some of the pipes may be corroded. In case of a fire associated with a transformer, water sprayed through corroded pipes could contain corroded particles that may cause further damage to the equipment.

Testing of the transformer WDSs are difficult as they are critical assets and need to be taken out of service for tests. Normally they are tested after planned maintenance works on the transformers they are associated with.

The [C.I.C] FSSs are expensive to maintain as they are subject to ten yearly maintenance programs which involve hydrostatic testing of cylinders and refilling of gas at designated workshops.

3.4.3 Short useful service life for FIPs

The suppliers / manufacturers of FIPs have recommended 15 years of useful service life for FIPs due to the involvement of software and electronic components which have a short life span. In addition, no condition assessment methodology is available to detect the imminent failure of an FIP which would enable proactive replacement before failure. However, the replacement is fairly simple and inexpensive and is based on functional failures (tested every month). Based on their age and useful life, provision has been made in work programs to replace these assets on failures supported by historical data. Several FIP and FDTS replacements are included in major rebuild projects.

4 Risk Assessment

The non-compliance of some FHS pipe work with the AS 2419.1, due to the inadequacies specified in section 3.4.1 poses a significant risk to firefighting operations.

FPSs and FSSs reduce the risk associated with fires by reducing the risk consequences if a fire does start. It will not however reduce the likelihood of a fire starting. The gaseous FSSs are installed only in three terminal stations and do not significantly contribute to a reduction in overall risk.

4.1 Consequences

The impact of a failure of FPSs and FSSs can vary significantly. The consequences could occur in one or more of the following areas:

- Health, safety and people;
- Environment and community;
- Reputation;
- Customers;
- Regulation Legal and compliance;
- Projects;
- Financial Impact.

To ensure that asset failures are unlikely to constrain supplies to customers or compromise the security of the National Electricity Market (NEM), the electricity transmission network employs high levels of redundancy in primary circuits and secondary circuits, including:

- EHV electrical equipment is arranged in redundant circuits within each terminal station;
- EHV transmission lines are arranged in redundant meshed and looped circuits throughout Victoria;
- Protection, control and instrumentation functions are duplicated or backed up; and
- Data streams are transmitted by redundant circuits over duplicated routes.

Nevertheless, a fire in a terminal station control building or relay building may result in a loss of supply from the station for a long duration. Similarly the loss of critical equipment such as a major system transformer due to a fire could constrain the network power flows during periods of peak demand.

Fire associated with transformers, bulk oil circuit breakers, etc, can be very damaging and difficult to extinguish due to the large volumes of mineral insulating oil in them. Correct functioning of fire detectors is very important to detect the fire early enough to manage and extinguish the fire without extensively damaging the assets in the terminal stations and potentially neighbouring properties.

Depending on the location where the fire starts, there is a tendency for a fire to spread to other areas through cable ducts. To prevent this, cable entry points need to be properly sealed using appropriate fire rated material.

The loss of a transformer and associated damage is likely to be within the range [C.I.C] to [C.I.C] and therefore is rated 3 on the consequence scale of AusNet Services' risk assessment matrix.

4.2 Likelihood

AMS 20-67 shows 12 major transformer failures since 1978 and a more recent failure at BETS has occurred. Of these, one failure ignited a fire which caused major damage to the transformer. The prevailing transformer MTBF is 1.4 years or a failure probability of approximately 70% p.a. With one fire from 13 failures the probability of a major transformer fire is 8%. 70% x 8% = 6%. 6% corresponds to a Likelihood of B or "Unlikely > 1%" on AusNet Services' risk assessment matrix.

4.3 Risk Controls

Fire protection measures are in place to mitigate the risk of fires by reducing the fire consequences. Many of these measures are the requirements outlined in AusNet Services' Station Design Manual.[2] There is a possibility that these measures will not be operational at the time they are needed and therefore they are assessed as 'Partially Effective'. The effectiveness of control measure is maintained and improved by undertaking maintenance on systems and by replacing systems that have an elevated probability of failing to perform.

There are standard maintenance instructions for all fire protection equipment, which are performed at intervals in accordance with the AS1851. The majority of the compliance testing and maintenance (eg. levels 1, 2, 3, 4 and 5) are performed by professional fire service contractors.

FHS replacement projects detailed in section 3.3.5 will help mitigate the risks posed by non-compliant underground pipework supplying FHSs.

4.4 Risk Matrix

Figure 10 shows the reduction of risk associated with FDSs and FSSs through the planned asset replacement program. The program is planned to ensure the levels of risks remain below acceptable limits. The implementation of this planned asset replacement program will not change the consequence of a fire in a terminal station. The likelihood of a fire will be reduced by the planned program however the likelihood is not expected to reduce from its current Unlikely level to Rare.

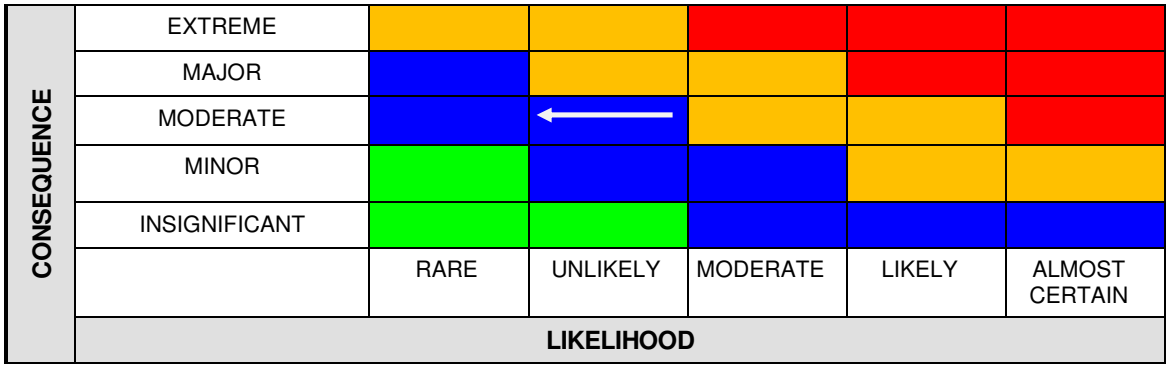

Figure 10 – Risk matrix

[2] Station Design Manual – Volume 5.

5 Strategies

Key asset management strategies for fire detection and suppression include:

- Continue regular inspection and tests for all FPSs in accordance with the relevant Australian Standards (AS1851).
- Ensure completion of the fire risk study proposed to assess the effectiveness of [C.I.C] systems.
- Progressively replace all the remaining FHSs in C4 and C5 conditions with systems complying with relevant Australian Standards by the end of 2022.
- Refurbish / replace WDSs that are in C4 and C5 conditions.
- Retrofit adequate fire protection measures for spare transformers at HWTS and SMTS.
- Replace failing smoke detectors and FIPs in Control Buildings.