NEED/OPPORTUNITY STATEMENT (NOS)

Forbes No.1 and No.2 Transformer Replacement

NOS- DCN276 revision 2.0

Ellipse project no.: P0001238
TRIM file: [TRIM No]

Project reason: Capability - Asset Replacement for end of life condition
Project category: Prescribed - Replacement

Approvals

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Change history

Revision	Date	Amendment
0	6 May 2016	Initial issue.
1	14 November 2016	Updated risk scores and minor wording.
2	22 November 2016	Update to format

1. Background

Forbes Substation is equipped with two transformers, both rated at 132/66/11kV and 60MVA. These two transformers are supplying an average load of approximately 20MVA (peak load in the last two years is around 35MVA), consisting mainly of light commercial and residential load. Forbes loads can be alternatively supplied via Essential Energy interconnected system between Parkes and Cowra.

2. Need/opportunity

2.1 No.1 Transformer

The Forbes No. 1 transformer has reached an end-of-life condition due to extensive carbon particle contamination of the windings. An unacceptable and increasing risk of failure exists. Risks are presently managed to a degree by operating the transformer on fixed tap to prevent the introduction of additional carbon material into the main tank.

The impact of placing the Forbes transformers on fixed tap is to increase the work done by tapchangers on transformers supplied from Forbes. The downstream tapchangers will hence require overhaul and replacement at an earlier time. Lack of functioning tapchangers at Forbes also leads to a need to operate the surrounding system to control the voltage range at Forbes and under some system conditions; voltage control is insufficient at the customer supply point as a result of the reduction in total tapping range.

The following supporting evidence describes the condition of the transformer (and detailed information is available in the accompanying condition assessment):

Defect History:

The transformer has a history of minor oil leaks on the main tank, and significant leaking/cross contamination of main tank oil from the diverter switch cylinder oil. There is a history of a serious winding mechanical fault which was incurred during lifting of the core during refurbishment work in 1998 which was subsequently repaired, and a tapchanger failure in 2002.

Oil quality:

Oil quality parameters other than DDF and Resistivity (Danger level) are in the acceptable range as per the Substations Condition Monitoring Manual, with fluctuating DBS results during the transformer lifetime. However there are clear indications that oil replacement/treatment work in 1998 was ineffective as indicated by decrease in oil quality since that time.

Moisture in oil measurements (used to estimate moisture in paper) are unclear and estimates of moisture in paper (2.8%) are unlikely to be reliable due to low transformer temperatures during oil sampling. It is likely that in the case of this transformer, estimation of moisture using dielectric response testing will not be effective due to the presence of extensive carbon through the tank and windings.

An oil conservator separator bag was fitted in 1998.

PCB measurements on this transformer (~1ppm) indicate the oil should be categorised as PCB Free.

Paper Insulation system:

Relatively low furan count (0.04ppm) indicates an average ageing rate for this transformer. Significant carbon contamination from DSW cross contamination is also indicated by high winding DDF. Whilst an internal inspection has not been carried out on this transformer, similar work has been completed for No.2 Transformer at this Substation which confirmed the extent of contamination. Given the nature of the service connection for both transformers and their similar history it is considered reasonable to expect that similar internal conditions exist for

No.1 transformer. Advice from the transformer manufacturer is that removal of carbon contamination is unlikely to be complete even if subjected to solvent washing in at the factory and subsequent vapour phase treatment.

Dissolved Gas Analysis:

Serious gas trends are due to the older D type diverter switches which have a known history of poor sealing and cross contamination of switch cylinder oil with the main tank oil. Both Forbes transformers have been on fixed tap since refurbishment of No.2 Transformer in June 2008, with a commensurate decrease in gas generation as a result.

The presence of gasses from the diverter switch results in a loss of diagnostic ability using DGA analysis of oil from the main tank.

Bushings:

Original Micafil SRBP type bushings were replaced in 2010 in accordance with Asset Strategy 4882 and all dielectric measurements are within policy requirements

Tap Changer and Diverter Switch:

D type diverter switches are known to leak oil/gas into the main tank and inspection by OEM during previous work has confirmed leaking issue. Rectification of sealing problems requires factory disassembly due to transformer construction. The switches are unable to be removed without lifting the main tank lid and removing the core – which would be best completed in a workshop environment. Rectification of the cross contamination issue will at a minimum require replacement of bakelised paper diverter switch cylinders with more modern fibreglass/resin types.

The diverter switches on this transformer have completed less than 100,000 operations (with an operational life of 800,000 operations as per manufacturer's advice) which is average for a transmission transformer of this age. Selector switch has no known or apparent issues.

The associated auxiliary transformer requires replacement as a result of chronic oil leaks and is also unbunded.

The Forbes No.1 Transformer is affected by carbon contamination and is at an increased risk of failure. The transformer cannot provide voltage regulation in its present condition without adding to the operating risk.

2.2 No.2 Transformer

The Forbes No. 2 transformer has extensive carbon particle contamination of the windings. An unacceptable and increasing risk of failure exists. Risks are presently managed to a degree by operating the transformer on fixed tap to prevent the introduction of additional carbon material into the main tank.

The impact of placing the Forbes transformers on fixed tap is to increase the work done by tapchangers on transformers supplied from Forbes. The downstream tapchangers will hence require overhaul and replacement at an earlier time. Lack of functioning tapchangers at Forbes also leads to a need to operate the surrounding system to control the voltage range at Forbes and under some system conditions; voltage control is insufficient at the customer supply point as a result of the reduction in total tapping range.

The following supporting evidence describes the condition of the transformer (and detailed information is available in the condition assessment):

Defect History:

The transformer has a history of minor oil leaks on the main tank, and significant leaking/cross contamination of main tank oil from the diverter switch cylinder oil.

Oil quality:

Oil quality parameters other than resistivity (Caution range) are in the acceptable range as per the Substations Condition Monitoring Manual, but appear to be trending upwards after refurbishment work in 2008. Moisture in oil measurements (used to estimate moisture in paper) are unclear and estimates of moisture in paper (<1%) are unlikely to be reliable due to low transformer temperatures during oil sampling. It is likely that in the case of this transformer, estimation of moisture using dielectric response testing will not be effective due to the presence of extensive carbon through the tank and windings. However, recent test results indicate a moisture content of 1.8%.

PCB measurements on this transformer (~1ppm) indicate the oil should be categorised as PCB Free.

Paper Insulation system:

Relatively low furan count (0.54ppm is the worst case assuming that levels prior to the refurbishment in 2008 are additive to present levels) indicates an average ageing rate for this transformer. Significant carbon contamination was discovered and flushing during refurbishment work in 2008 may not have been completely effective as indicated by decreasing resistivity levels. Advice from transformer manufacturer is that removal of carbon contamination is unlikely to be complete even if subjected to solvent washing at the factory and subsequent vapour phase treatment.

Dissolved Gas Analysis:

Serious gas trends are due to the older D type diverter switches which have a known history of poor sealing and cross contamination of switch cylinder oil with the main tank oil. Both Forbes transformers have been on fixed tap since refurbishment of this transformer in June 2008, which has resulted in a decrease in gas generation.

The presence of gasses from the diverter switch results in a loss of diagnostic ability using DGA analysis of oil from the main tank.

Bushings:

Original Micafil SRBP type bushings were replaced in 2010 in accordance with Asset Strategy 4882 and all dielectric measurements are within policy requirements

Tap Changer and Diverter Switch:

D type diverter switches are known to leak oil/gas into the main tank and inspection by OEM during previous refurbishment work in 2008 has confirmed leaking issue. Rectification of sealing problems required factory disassembly due to transformer construction, where the switches could be removed (requires lifting the main tank lid and removing the core). Rectification of cross contamination issue was considered at the time of the work in 2008 and required replacement of the bakelised paper DSW cylinders with more modern fibreglass/resin types. The significant internal work required could not be completed onsite and effective resolution of the cross contamination problem remained incomplete. The diverter switches on this transformer have completed less than 100,000 operations (with an operational life of 800,000 operations as per manufacturer's advice) which is average for a transmission transformer of this age. Selector switch has no known or apparent issues.

The associated auxiliary transformer requires replacement as a result of chronic oil leaks and is also unbunded.

2.3 Risk cost of No.1 and No.2 Transformer

The associated total risk cost of No.1 Transformer is $0.2m per year and $0.1m per annum for No.2 Transformer. In addition, there are risks associated with the circuit breakers and secondary systems which should be considered when evaluating the options to address the transformers and the development of an appropriate solution. The total risk of all of these assets is $0.7m.

Exposure to these risks should be minimised and replacement prior to 2023 is achievable and is thought to be in sufficient time to prevent development of a fault that could lead rapidly to failure of the transformer.

3. Related needs/opportunities

- Inspection and minor refurbishment of ex-Wagga 132kV No.1 Transformer
- Replacement of associated two auxiliary transformers
- Replacement of associated 66kV circuit breakers and 66kV current transformers with dead tank circuit breakers.
- Replacement of associated protection and control systems.
- Replacement of transformers' metering systems

4. Recommendation

It is recommended that options be considered to address the identified need.

Current Option Assessment - Risk Summary

Project Name: Transformer Forbes No. 1

Option Name: DCN276a - Base Case

Option Assessment Name: DCN276a - Base Case for Tx1

Rev Reset Period: Next (2018-23)

Major Component	No.	Minor Component	Sel. Hazardous Event	LoC x CoF ($M)	Failure Mechanism	NoxLoC xCoF ($M)	PoF (Yr 1)	Total Risk ($M)	Risk ($M) (Rel)	Risk ($M) (Op)	Risk ($M) (Fin)	Risk ($M) (Peo)	Risk ($M) (Env)	Risk ($M) (Rep)
Main Transformer	1	Winding and Core	Explosive Failure of Asset (Main Transformer)	$0.11	Failure	$0.11	4.24%	$0.00			$0.00	$0.00		$0.00
Main Transformer	1	Winding and Core	Failure that Releases Pollutant (Main Transformer)	$0.00	Failure	$0.00	4.24%	$0.00			$0.00		$0.00	$0.00
Main Transformer	1	Winding and Core	Unplanned Outage - HV (Main Transformer)	$4.80	Failure	$4.80	4.24%	$0.20	$0.10		$0.10			$0.00
				$4.91		$4.91		$0.21	$0.10		$0.10	$0.00	$0.00	$0.00

Total VCR Risk: $0.10

Total ENS Risk: $0.00

Current Option Assessment - Risk Summary

Project Name: Transformer Forbes No. 2

Option Name: DCN276b- Base Case

Option Assessment Name: DCN276b- Base Case for Tx2

Rev Reset Period: Next (2018-23)

Major Component	No.	Minor Component	Sel. Hazardous Event	LoC x CoF ($M)	Failure Mechanism	NoxLoC xCoF ($M)	PoF (Yr 1)	Total Risk ($M)	Risk ($M) (Rel)	Risk ($M) (Op)	Risk ($M) (Fin)	Risk ($M) (Peo)	Risk ($M) (Env)	Risk ($M) (Rep)
Main Transformer	1	Winding and Core	Explosive Failure of Asset (Main Transformer)	$0.11	Failure	$0.11	2.84%	$0.00			$0.00	$0.00		$0.00
Main Transformer	1	Winding and Core	Failure that Releases Pollutant (Main Transformer)	$0.00	Failure	$0.00	2.84%	$0.00			$0.00		$0.00	$0.00
Main Transformer	1	Winding and Core	Unplanned Outage - HV (Main Transformer)	$4.80	Failure	$4.80	2.84%	$0.14	$0.07		$0.07			$0.00
				$4.91		$4.91		$0.14	$0.07		$0.07	$0.00	$0.00	$0.00

Total VCR Risk: $0.06

Total ENS Risk: $0.00