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Entergy Nuclear Northeast
Power Transformer Spare Purchase Recommendations
January 4, 2006
John Bonner

Summary of Priorities

An assessment of the Entergy Nuclear Northeast fleets large power transformers was performed to determine the potential risk of loss and impact of a loss on the operation of the associated generator. This report is the second of two assessments requested by Entergy Nuclear Northeast Engineering Management. The first assessment addressed the fleet's generator step-up transformers (main transformers) and this assessment addressing the balance of larger power transformers.

The findings of the assessment were used to develop a spare transformer purchase priority list. The two highest risk transformers based on their age, operating history and impact on generating are, in order of priority:

1. Vermont Yankee Unit Auxiliary Transformer
2. Fitzpatrick Unit Auxiliary Transformer

Introduction

This report provides priority listing and basis for the purchase of spare large power transformers of Entergy Nuclear Northeast fleet. The priorities and recommendations are based on a condition assessment and review of the criticality of a transformer to the continued operation of the associated unit. The factors considered in the assessment are described in the report.

This report was limited to large power transformers where an acceptable spare is not available within the fleet. The report does note any potential spare transformer design or configuration issues, which were identified during the review.

The report does not assess the impact of an in-service transformer failure. The report does consider the impact on the loss of the transformer on continued operation. It should be noted that an in-service failure of many of the transformers included in this assessment would result in the trip of the generator.

This report does not include the fleet Main Transformers. The Main Transformer spare purchase recommendations have been provided in a separate report issued early in 2005.

Overview

The initial steps in the assessment were to determine, what on-site spare transformers exist and if there are any commonality between the power transformers in the Entergy Nuclear Northeast fleet.

Pilgrim has spare transformers for two of their three power applications. Indian Point and Fitzpatrick have an on-site spare for their primary off-site power source. Vermont Yankee does not have any on-site spare transformers, with the exception of the Main Transformers.

It was determined, with the exception of Indian Point Units 2 and 3, that there are no commonalities between the transformers within the Entergy Nuclear Northeast fleet. This is primarily because of the various off-site power voltage sources and the main generator nominal terminal voltages.

There are a number of power transformers that if lost would require a station shutdown per Technical Specification requirements or require a reduction in unit output.

Assessment Factors

The following were the primary factors considered during the assessment:

- Transformer age
- Transformer normally loaded
- Transformer normal loading and percentage of loading with respect to the transformer rating
- DGA testing results
- Transformer physical condition
- Impact on the station if the transformer were to be removed from service (TS limitations)
- Availability of a replacement unit
- Existing spare units
- Off-site power considerations
- Flexibility of spare unit to support multiple site or applications

Site Assessment Summary

Pilgrim

Pilgrim has two new on-site spares for power transformers (Unit Auxiliary and Startup Transformers); therefore only the Shutdown transformer is included in this assessment. Note: The installed unit auxiliary transformer is currently out of service for repair or replacement. A fair chance exists that the spare will be installed this month.

- Shutdown Transformer

The Pilgrim 23kV Shutdown transformer is an original unit over 30 years old. It is normally energized but not loaded. In fact, the transformer is only loaded during refueling outages, and during once per cycle testing; therefore, the time when the unit is loaded is less than 5% of the time. Therefore, the transformer condition, from an in-service standpoint, is very good and the 30 to 40 year normal service does not apply.

There are no identified problems with the shutdown transformer and its overall condition is considered as good.

The rating and configuration of the transformer makes it a relatively common type unit and the replacement transformer availability is considered fair to good.

The loss of the unit would place Pilgrim into a 7-day shutdown LCO. This makes it a critical component, and its loss would have a serious impact on generation.

- Conclusions

Pilgrim has a spare transformer for all large power transformers except the shutdown transformer. The purchase of spare shutdown transformer is considered a low priority when assessed against the other fleet needs based on the following:

- The shutdown transformer is unloaded for the preponderance of the time - over 95%. Therefore the 30 – 40 year normal transformer service life is not a consideration.
- The overall condition of the shutdown transformer is good.
- The rating and configuration of the shutdown transformer is relatively common; and a replacement unit should be available.
- The loss of the shutdown transformer would require the shutdown of the Pilgrim within 7days.
- The cost of a spare unit would be relatively inexpensive (\$150k to \$200k) with respect to the cost of other station power transformers,

Fitzpatrick

Fitzpatrick has three transformers included in this assessment, the Unit Station Service and two Reserve Station Service transformers.

- Unit Station Service Transformer

The Unit Station Service transformer is an original unit, which is loaded during normal station operation. The failure of the Unit Station Service transformer would result in the trip of the unit and transfer of station loads to the Reserve

Station Service transformers. Fitzpatrick could restart and continue operation without the Unit Station Service transformer but it would be required to operate at a reduced output ($\approx 80\%$ in the winter and 70% in the summer). During this period the unit would be provided power from the Reserve Station Service transformers.

Normal loading on the Unit Station Service transformer is approximately 90% of its design rating; therefore the anticipated 30 – 40 year service life of the transformer would be extended. The present condition of the transformer appears fair to good. The transformer and load tap changer dissolved gas analysis (DGA) results are good for a transformer of this in-service age and loading.

The availability of a replacement transformer is unlikely, primarily because the transformer is equipped with a load tap changer. The normal fabrication and delivery of a replacement transformer would be 9 -12 months upon receipt of an order.

- Reserve Station Service Transformers

Reserve Station Service transformers are original units, which are normally energized but unloaded during normal operation. The loss of a reserve station service transformer would place Fitzpatrick into a 7-day shutdown LCO. There is an on-site spare reserve station service transformer, which has not been in service and would meet the needs of the Fitzpatrick. The transformers are in good condition for their age and no operational issues have been identified.

There is a secondary issue associated with the 115kV off-site power supply, which is being addressed by engineering. The issue concerns the ability of one of the two off-site power sources to provide acceptable post trip voltage if the primary line were out-of-service and a heavy system loading conditions. One of the options being considered is the installation of load tap changing capability on the 115kV off-site source to increase voltage at Fitzpatrick's safety buses. Nine Mile Point Unit 1 has a similar 115kV supply voltage issue and has replaced their Reserve Station Service transformers with transformers equipped with load tap changes.

- Conclusion

The purchase of a spare Unit Station Service transformer is considered a high priority based on the following:

- Operating without the unit auxiliary would limit unit generation to approximately 80% in the winter and 70% in the summer of rated.
- A replacement unit would require 9 – 12 months. The availability of an acceptable spare unit would be unlikely because the physical configuration and the unit having a load tap changer.

- The existing unit is operating an approximately 90% or rated capability, therefore its anticipated in-service life would be longer than the expected 30 – 40 years.
- The overall condition of the Unit Station Service transformer is good.

The purchase of a spare Reserve Station Service transformer is considered a low priority based on the following.

- Fitzpatrick has an on-site spare reserve station service transformer.
- There is an off-site 115kV system post trip voltage issue which would be improved with the installation of two reserve station service transformers with fast load tap changers.

Vermont Yankee

Vermont Yankee has the largest number of larger power transformers and has no spare units on-site. Many of these transformers are required for unit operations because of the Vermont Yankee's off-site power configuration which takes credit for the power that station with a backfeed through Main and Unit Auxiliary transformers.

Vermont Yankee has five transformers (Unit Auxiliary Transformer, two Startup Transformers, 345kV Autotransformer and the Vernon Tie SBO supply), which the loss of any one would place the unit in a shutdown LCO. All these transformers are over 30 years old.

The following Vermont Yankee power transformers were included in this assessment:

- ◆ Unit Auxiliary Transformer which also credited as a delayed off-site power source.
- ◆ Two Startup Transformers which are the immediate off-site power source.
- ◆ 345kV Autotransformer which is required to maintain an acceptable 115kV off-site post trip voltage to the Startup Transformers.
- ◆ Vernon Hydro Supply Transformer which is required for Vermont Yankee to meet its station blackout recovery requirements. Its loss would place Vermont Yankee into a 14-day administrative shutdown LCO
- ◆ Two Cooling Tower transformers which are required for Vermont Yankee to operate at full power.
- Unit Auxiliary Transformer

The Unit Auxiliary transformer is normally loaded during normal operation and at approximately 90% of its design rating. There are no identified problems with the transformer.

The powering of the Unit Auxiliary transformer by backfeeding the Main transformer from the 345kV lines is credited as Vermont Yankee's second Tech Spec off-site power source. The loss of the Unit Auxiliary transformer would place Vermont Yankee into a 7-day shutdown LCO during which time the unit would be powered from the two Startup transformers. The failure of the Unit Auxiliary transformer on-line would result in the trip of the unit and fast transfer of house loads on to the Startup Transformers.

Because of the phasing configuration and transformer connections, the availability of an acceptable spare unit is unlikely. Therefore based on the age, in-service loading and impact on the operation of the Vermont Yankee station, the purchase of a spare Vermont Yankee Unit Auxiliary transformer is considered to be the most critical.

- Startup Transformer

Both of the Vermont Yankee Startup Transformers are energized during normal unit operation. Startup transformer T-3-A is normally unloaded. Startup transformer T-3-B provides off-site power to for the cooling towers during summer operation and will be required to provide continuous cooling tower power after the Vermont Yankee power uprate is implemented. The cooling tower loading is approximately 40% of unit rating. This is an insignificant duty, since loading/heating is proportional to the square of the current. There are no identified problems with either of the two Startup transformers.

The two Vermont Yankee Startup transformers provide the immediate Tech Spec off-site power source. The loss of either transformer would place Vermont Yankee in a 7-day shutdown LCO.

Because of the Vermont Yankee phasing configuration an available spare is unlikely to be located.

A single spare startup transformer could support the loss of either transformer. Therefore the purchase of a spare Vermont Yankee Startup transformer is considered of a high priority.

The purchase of spare unit startup transformer with a fast load tap changer should be considered. The installation of load tap changer equipped transformer in place of the unit supplying the cooling tower loads would help resolve some of the 115kV voltage restriction and reduce the importance of the 345kV Autotransformer.

- 345kV/115kV Autotransformer

The 345kV Autotransformer which is located in Vermont Yankee switchyard is the primary source of power to the 115kV switchyard and Vermont Yankee

immediate off-site power source via the Startup transformers. Transmission studies have shown that the 345kV Autotransformer is required to ensure adequate post trip 115kV system voltage. Since the Vermont Yankee station requires an 115kV system voltage above the transmission system acceptable voltage levels, the loss of the Autotransformer would most likely place Vermont Yankee into a 7-day shutdown LCO.

The 345kV Autotransformer is normally lightly loaded on information from VELCo . Its condition is fair to good. There is a small oil leak which is being monitored and will be repaired during the next refueling outage.

There is an installed spare unit at VELCo's West Rutland substation which was purchased and installed to improve system reliability. Discussions with VELCo have concluded that VELCo would not consider the disconnection and moving the unit to replace a failed transformer at Vermont Yankee. This decision was based on the risk to transmission system reliability of not having the installed West Rutland spare unit for a period 9 to 14 months until a repair Vermont Yankee transformer or new transformer became available.

The issue of purchasing a spare 345kV Autotransformer is more complex than the other transformers. The 345kV Autotransformer is part of the IOS-NE bulk transmission system therefore a spare transformer would be the responsibility of the transmission owner and would be funded through the transmission tariffs. Since Entergy Nuclear Northeast is not classified as a tariff support transmission owner we presently don't have this finance option.

Entergy is in the process of evaluating the potential sale or transfer of the Pilgrim and Vermont Yankee switchyards. This sale or transfer would make it possible for the new owner to purchase and install a spare autotransformer to improve system reliability.

Discussions with VELCo about installation of a VELCo purchase of an owner spare autotransformer in the Vermont Yankee switchyard to improve system reliability was discontinued because of the potential sale/transfer of the Vermont Yankee switchyard.

The cost of a spare 345kV autotransformer would be \$2.5M – \$3.2M and would take 9 – 14 months upon receipt of order.

The Vermont Yankee 345kV Autotransformer is a critical off-site and transmission system reliability element. The failure of the unit would most like result in Vermont Yankee being required to shutdown because of inadequate post trip 115kV system voltage. The potential that the Vermont Yankee switchyard maybe sold or transfer during 2006 is considered fair. Once the switchyard is transferred it would take another 6 – 9 months to receive approval for the purchase of an installed spare Vermont Yankee switchyard 345kV

autotransformer for ISO-NE. Therefore we could be look the third quarter of 2008 before we have a spare unit on-site.

Purchase of a spare autotransformer for Vermont Yankee will need to be revisited once a final determine of the future of the Vermont Yankee switchyard has been made. More details should be available by mid-February 2006.

- Vernon Tie (Station Blackout Coping Supply) Transformer

The Vernon Tie transformer provides Vermont Yankee Station Blackout recovery power in the event of a loss of all AC at Vermont Yankee. The transformer is connected to the Vernon Line, which in the event of blackout would be reenergized from the Vernon Hydro unit with 120 minutes. The loss of the Vernon Tie transformer would place Vermont Yankee into a 14-day administrative shutdown.

The transformer is an original unit and is normally deenergized therefore the normal 30-40 year service life does not apply.

There are no identified problems with the transformer and the transformer's rating and configuration is common. An acceptable replacement unit could be located, shipped and installed with in the 14-day limitation.

- Cooling Tower Transformer

The two cooling tower transformers are both new having been purchased to support the power uprate. The loss of one transformer may result in the need to back down the unit depending on river water flow. The rating and configuration of the transformers are common and an acceptable replacement could be located and transported within a week to ten days.

The purchase of a spare Vermont Yankee Cooling Tower transformer is considered low priority.

- Conclusions:

The purchase of a spare Unit Auxiliary transformer is considered a top priority based on the following:

- The loss of the Unit Auxiliary transformer would require the shutdown of Vermont Yankee.
- A replacement unit would require 9 – 12 months. The availability of an acceptable spare unit would be unlikely because of Vermont Yankee phasing and physical configurations.

- The existing unit is operating an approximately 90% or rated capability, therefore its anticipated in-service life would be longer than the expected 30 – 40 years.
- The overall condition of the Unit Auxiliary is good.

The purchase of a spare Startup transformer is considered a high priority based on the following.

- The loss of either Startup transformer would require the shutdown of Vermont Yankee.
- A replacement unit would require 9 – 12 months. The availability of an acceptable spare unit would be unlikely because of Vermont Yankee phasing and physical configurations.
- The T-3-B transformer is loaded approximately 40% or rated capability, therefore its anticipated in-service life would be longer than the expected 30 – 40 years.
- The overall condition of the Unit Auxiliary is good there is an off-site 115kV system post trip voltage issue which would be improved with the installation of a new Startup transformer with fast load tap changers at the T-3-B location.

The purchase of a spare 345kV Autotransformer needs further evaluation after the ownership status of the Vermont Yankee switchyard has been determined. Assuming the ownership Vermont Yankee switchyard is not sold or transferred, the purchase of a spare 345kV Autotransformer is considered median to high priority based on the following

- 345kV Autotransformer is an original unit having been in service for over 30-years.
- The Autotransformer is normally lightly loaded therefore the 30-40 year service life can be extended.
- The loss of the Autotransformer would most likely place Vermont Yankee into a 7-day shutdown LCO.
- The availability of an acceptable spare unit would be unlikely because of Vermont Yankee phasing and physical configurations. In addition, the physical size of the unit would greatly increase the time need to transportation as replacement unit.
- The purchase of a replacement unit would require 9 – 14 months.
- The cost of a new spare Autotransformer would be \$2.5M – \$3.2M, this amount of funding could be better spent fill multiple spare transformer arrears.

The purchase of a spare Vernon Tie transformer is considered a mid to low priority based on the following:

- The loss of the Vernon Tie transformer would place Vermont Yankee into a 14-day shutdown.
- The transformer is normally deenergized therefore the 30-40 service life does not apply.
- The transformer is a fairly common rating and configuration therefore an acceptable replacement could be located within 14 days.
- The overall condition of the Unit Auxiliary is good.

The purchase of a spare Cooling Tower transformer is considered a low priority based on the following:

- The Cooling Tower transformers are new.
- The transformer is a fairly common rating and configuration therefore an acceptable replacement could be located.
- The loss of a single unit may require the backdown of Vermont Yankee depending on river flow.

Indian Point Energy Center Unit 2 and 3

Indian Point has the advantage that a spare transformer can be used to support both units. Therefore, the economics behind any purchase of a spare unit is favorable. In addition, the size of the units over 1000MWe reinforce the cost-risk benefit of have adequate on-site spares.

The following Indian Point Energy Center power transformers were included in this assessment:

- ◆ Unit 2 and 3 Unit Auxiliary Transformers
- ◆ Unit 2 and 3 Station Auxiliary Transformers which are the immediate off-site power source. IPEC has two on-site spare Station Auxiliary transformers.
- ◆ Two 13.8kV Reserve Transformers which are the delayed off-site power sources.
- Unit Auxiliary Transformers

The two Unit Auxiliary transformers are original units, which are loaded during normal station operation. The failure of the unit auxiliary would result in the trip of the unit and transfer of station loads on the Station Auxiliary transformers. IPEC Unit 2 or 3 could continue operation using the Station Auxiliary transformer if the Unit Auxiliary transformer became unavailable.

During operation the Unit Auxiliary transformer is loaded at approximately 91%, therefore the anticipated 30 – 40 year service life of the transformer would be extended. The present condition of the transformer appears fair. There are minor

load tap changer enclosure oil leaks and sticking of the tap changer. IPEC is planning tap changer maintenance or a replacement during the next refueling outage.

The availability of a replacement transformer is unlikely primarily because the transformers are equipped with a load tap changer. The normal fabrication and delivery time of a replacement Unit Auxiliary transformer would be 9 -12 months upon receipt of an order.

A spare Unit Auxiliary transformer is considered to be mid to high priority because of the age of the unit and the load tap changer issues. Since the internal tap changer maintenance or a possible replacement could have an impact on the refuel outage schedule it is recommended that a spare Unit Auxiliary be purchased in time to support the refueling outage. The new Unit Auxiliary transformer could then be installed during an outage and the removed Unit Auxiliary can then be overhauled off-line and used to replace the other Unit Auxiliary transformer. This would leave IPEC with a spare Unit Auxiliary transformer.

- Station Auxiliary Transformers

The Unit 2 and 3 Station Auxiliary transformers provide IPEC immediate off-site power. The transformers are equipped with load tap changers. The loss of the Station Auxiliary transformer would place the associated unit into a 72-hour shutdown LCO. The transformers' overall condition is fair with minor oil leaks in the tap changer enclosures. There are also some issues with the tap changer sticking during step changes. These conditions are being monitored by the station and corrective action is being planned.

IPEC has two spare Station Auxiliary transformers on-site. The physical configuration, transformer impedance, load tap rating and speed need to be reviewed to ensure the acceptability of the spare units. IPEC off-site power design requirements depend on the ability of the Station Auxiliary transformers to rapidly increase 6.9kV system voltage by overriding the load tap changer step-by-step tap changing process and drive the load tap changer to its maximum tap.

The Station Auxiliary transformers are over 30 years old and are normally loaded at approximately 20% of their design rating.

Therefore IPEC needs to perform a detailed design review of the acceptability of the two spare Station Auxiliary transformers. The review should include the following:

- System load flow studies based on the transformer impedance
- Tap changer speeds

- Determine what modifications need to be made to install the unit (i.e. Circuit changes to overriding the step-by-step tap change, connection requirements for the larger ASEA spare transformer).
 - Develop the necessary design packages and purchase the need interface material to support the installation of the spare transformer, which is identified as the preferred spare.
 - Operating condition of the spare transformer tap changers.
- 13.8kV Off-site Power Transformers

The Units 2 and 3 second off-site power source are relayed manually aligned 13.8kV sources to IPEC 6.9kV Buses if a Station Auxiliary transformer becomes unavailable. Each of the transformers can be aligned to supply either IPEC Unit. Therefore, the loss of a single 13.8kV Off-site Power transformer does not appear to place the either unit in an off-site power LCO. In addition, the condensate polisher loading from normally supplied for the Unit 3 transformer can be transferred to the Unit 2 transformer if the Unit 3 transformer were to fail.

Both transformers are normally energized during operation. The unit 2 transformer is normally unloaded and the Unit 3 transformer normally carries a light condensate polisher load. The IPEC Unit 3 transformer is over 30 years old. The unit 2 transformer has been replaced in 1999 with a dry-type unit.

There are no identified issues with the IPEC 13.8kV Off-site Power transformers and the ratings and configurations are fairly common. The ability to obtain and install a replacement 13.8kV transformer within 72-hour would provide a challenging task but this doesn't appear to be an issue if the loss of one 13.8kV Off-site Power transformer doesn't result in an off-site power LCO.

The rating of the transformer is fairly common and an acceptable spare could be located and obtained within a week to ten days.

- Conclusions:

The purchase of a spare Unit Auxiliary transformer is considered a mid to high priority based on the following:

- IPEC could operate on the loss of the Unit Auxiliary transformer.
- The existing unit is operating at approximately 91% of rated capability therefore its anticipated in-service life would be longer than the expected 30 – 40 years.
- The overall condition of the Unit Auxiliary is fair with minor tap changer issues.
- The purchase of a spare Unit Auxiliary transformer could be used to resolve tap changer issues without impacting the refuel outage schedule.

- A spare Unit Auxiliary transformer could be used by either Unit 2 or Unit 3.

The purchase of a spare 13.8kV transformer is considered low priority based on the following:

- IPEC could operate with the loss of one of the 13.8kV Off-site Power transformers.
- The 13.8kV Off-site Power transformers are normally unloaded or lightly loaded; therefore their anticipated in-service life would be longer than the expected 30 – 40 years of an oil-filled and 20 years for a dry type transformer.
- The Unit 2 transformer is not normally loaded and was replaced in 1999.
- The ratings and configurations of the transformers are fairly common and their availability is good.

Overall Priorities

1. The most critical spare transformer need is the Vermont Yankee Unit Auxiliary, because the units is normally loaded and its loss would require the shutdown of the Vermont Yankee until an acceptable replacement could be obtained and installed. The availability of an acceptable replacement is unlikely because of the Vermont Yankee's phasing and termination configurations.
2. The Fitzpatrick Unit Auxiliary transformer is classified as the second most critical spare because the units is normally loaded and its loss would require Fitzpatrick to operate at a reduced output level, approximately 80% in the winter and 70% in the summer until a replacement unit could be obtained. The availability of an acceptable replacement is unlikely because of the termination configuration.
3. A spare Vermont Yankee Startup transformer and 345kV Autotransformer have been classified as a second level priority because of Vermont Yankee off-site power requirements. The loss of either Startup or the 345kV Autotransformer would put Vermont Yankee into a 7-day LCO.

As previously discussed the future of the Vermont Yankee switchyard remains in questions and therefore the decision on the purchase of a spare 345kV Autotransformer needs to be relayed until the strategy of the Vermont Yankee switchyard is finalized.

Therefore, the purchase of a spare Vermont Yankee Startup transformer, which can support the loss of either transformer, was determined to be the third priority.

4. The fourth priority is a spare Indian Point Unit Auxiliary transformer that can be used to support either unit. The present transformers are original units and are normally loaded. Their removal from service of a Unit Auxiliary transformer would not require the shutdown of the unit.

A spare Indian Point Unit Auxiliary transformer should also be considered because the load tap changers on both units are scheduled for maintenance or replacement during the next refueling outages. Since the transformers and tap changers have been in-service of over 30 years completing the maintenance activities within the outage window could be challenging. A custom replacement Unit Auxiliary transformer could be installed and tested within a week. The removed transformer could then be overhauled prior to the other unit's outage and used to replace the other Unit Auxiliary transformer.

The remaining transformers, which don't have an on-site spares are prioritized as follows:

5. The IPEC 13.8kV transformer, which is support IPEC Tech Spec delayed off-site power source. The loss of a single unit does not appear to place either Indian Point Unit into an off-site power LCO. A spare transformer can be used by either unit.
6. Pilgrim Shutdown transformer, which is required for Pilgrim second Tech Spec off-site. The loss of the transformer would place Pilgrim in a 7-day shutdown LCO.
7. Vernon Tie Transformer, which is required to support Vermont Yankee SBO requirement. The loss of the transformer would place Vermont Yankee into a 14-day administrative LCO. The transformer size and rating is fairly common and an adequate spare could be obtained within the LCO period.
8. Vermont Yankee cooling tower transformers are both new. The loss of one of the transformer may require Vermont Yankee to operate at a reduce outage depending of river flow and temperatures.

Miscellaneous Item:

- The design adequacy of the two spare Indian Point Station Auxiliary transformers to meet the 138kV off-site voltage design requirements and installation configurations need to be verified.

If you have any questions or require additional clarification please contact John Bonner at 617-694-6094.