EN Large Power Transformer Status:

The following is an overview of information detailing the health of the large power transformers at the sites whose failure results in a SCRAM or Downpower. Separate reports are provided that define the site transformer attributes, spare transformer/ parts availability and pertinent transformer maintenance history including potential defects.

Transformer Failure Information

The following are potential failure modes obtained as a result of interviews with the fleets transformer Subject Matter Experts and are applicable to our transformers; a detailed review of latent transformer issues from the OEM has not currently been undertaken:

- Westinghouse 7 Million series transformers have a manufacturing deficiency that results in local hot spots internal to the transformer: the winding support steel generates eddy currents that create hot spots and gassing. Additionally; the original bushing to winding terminations in this series transformer were over insulated that resulted in poor oil circulation for these terminations and the generation of local hot spot (this is applicable to older transformers not excessively loaded whose profile increases due to power uprates or other load changes).

- GE type U bushings manufactured up to 1980 have a slow degradation mechanism that results in eventual failure. The issue is associated with HV, LV and neutral bushings provided by GE prior to 1980 to various transformer manufacturers. Spare bushings should be on hand in the event Doble measurements taken as part of the PM program indicate replacement required. HV bushing replacement lead times are excessive ~34 weeks.

- Gap type (i.e. Silicon Carbide) lightning arrestors have an inherent degradation mechanism where over time and based on the cumulative history of fault exposure results in failure without warning. It is suggested this type arrestor be changed to a newer type of arrestor ASAP.

- GE Dyna Compression Clamp Issue – over time the winding clamps become loose and no longer provide adequate restraint or support of the transformer windings. Internal inspection is the method to identify the condition and per options stated in literature an internal inspection may be the only way to determine if the Dyna Comp Clamp was used on a specific GE transformer.

Recommendation 1: A specific transformer where these issues may apply is indicated on the Maintenance History Report; these potential issues should be evaluated and actions taken to mitigate the risks, as appropriate. In addition; the transformer OEM should be contacted to determine if any latent issues pertain to a specific site transformer.

Protection from Catastrophic Transformer Failure

On line dissolved gas analyzers provide continuous monitoring of gases that define internal transformer health. These analyzers do not prevent transformer failure but provide advanced warning of transformer degradation that allows the transformer to be removed from service for repair rather than replacement. Of the 62 EN transformers in the subject population 8 have on-line analyzers installed (IPEC, PNPS and VTY on Main Transformers and WF3 on a

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Startup Transformer). Three sites (GG, PNPS, and RBS) have the purchase of monitors on the asset management plan for future purchase/upgrade. GG and RBS are waiting the outcome of the transformer SME working group prior to proceeding with the purchase and installation of analyzers; a fleet standard analyzer is required. The proposed population requiring analyzers is also being determined.

Recommendation 2: Install Dissolved Gas Analyzers on all site transformers at a minimum whose failure result in a SCRAM or a significant plant derate (2007 -2008 action).

Status Internal Transformer Inspection

The table provides data relative to the status of transformer internal inspections for the subject set of transformers. Transformers new or rebuilt within 5 years are credited with an inspection; those with an internal inspection performed ~10 years ago are identified since a new inspection may be warranted.

Table 1: Transformer Internal Inspection Data

Site	Transformers Inspected in population	Transformers inspected ~10 years ago	Planned transformer inspections
ANO	11/11	2	1
GG	6/14	1	1
IPEC	3/8	1	0
JAF	2/5	2	0
PNPS	2/4	none	0
RBS	4/9	none	2
VTY	1/5	none	0
WF3	4/6	none	1

Recommendation 3: Based on possible mitigation of catastrophic failure mechanisms transformer internal inspections should proceed on the fleet's older transformers ASAP to ensure reliability; the fleet has 11 transformers placed in service in late 1960 to mid 1970 that have not had internal inspections performed. Other transformers should be scheduled for inspection based on failure impact; all transformers should be inspected on a fixed frequency.

PM Program:

The information contained in the attached Maintenance History Report defines the current maintenance strategy being applied to the transformers. The applied maintenance strategies vary across sites and until the latest maintenance strategy has been applied a risk to the asset exists. The evaluation of the existing maintenance strategy to the latest maintenance strategy should be expedited by engineering across the fleet and any new or revised tasks issued and performed in the field per EN-DC-324 requirements.

The recent degradation of the ANO2 Main transformer resulted from the GE Dyna Compression Clamp which is used to support transformer windings was not able to provide its function. This failure indicates that dissolve gas analysis and other PM maintenance tasks are not sufficient to identify all non-random degradation mechanisms internal to the transformer since no indication of this degradation mechanism was observable with existing maintenance

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strategy. It is postulated that normal transformer vibration or through fault currents could have resulted in grounding of the windings resulting in transformer failure. The degradation was identified during an internal inspection triggered by external oil leaks and the transformer was replaced during the ANO outage as emergent work.

A review of the new transformer maintenance strategy defined by the PM Template using EPRI reliability software indicates an unprotected wear related failure mechanism that requires an internal transformer inspection to mitigate. This failure is loss of core ground due to vibration or ground faults.

Currently internal transformer inspection on the template has a frequency of "As Required" and performance of the inspection is only required based on results of other maintenance tests or transformer condition (leaks).

Recommendation 4: The latest maintenance strategy applicable to the sites transformers should be applied to the transformers with the new tasks implemented in the field as per EN-DC-324. The PM Template for transformers should be revised to require a fixed frequency internal inspection to identify degradation during planned outages.

<u>Spare Transformers/ Spare Parts</u>

If a transformer fails while energized it will result in tripping the connected busses and either result in a direct plant trip or a plant downpower. To restore the transformer will require either a spare to be installed or replacement parts. Those transformers without an available spare were verified to have a contingency plan; if no plan was provided on a aging transformer it was color coded red in Table 2. If data was provided from a site pertaining to the spare transformer currently available put not ready to install these transformers were color coded orange (this is not a complete list of fleet spares). Additionally; if spare parts are not available to support known failure potential they are color coded blue (Complete list of Transformer Spare data in attached report).

EPRI document: Large Transformer End of Expected Life Considerations and the Need for Planning, issued Dec 2006 (1013566) provides information relative to risk of transformer failure and replacement planning. This document has been sent to all site transformer SMEs for use. Based on industry data with a spare transformer available, staged adjacent to the transformer for replacement, a site should plan on 1 to 2 weeks for replacement. The time frames for the various scenarios vary but worst case would be the site has no spare and a replacement is not readily available in the industry; a site should plan on 84 to 88 weeks to procure, install, and test a new transformer.

Recommendation 5: Validate the health of the spare transformers at the sites and ensure they are being maintained. A new EN template will be issued for spare transformer maintenance and should be implemented in 2Q07. Additionally the spare parts not readily available should be in stock to ensure when preventive maintenance indicates replacement of degraded components is required. Verify for those transformers indicated RED in Table 2 have the appropriate contingency plan is applied. Those newer transformers without a contingency plan indicated in the attached report ensure a contingency plan is in place.

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Table 2: Site Spare Transformer/Issues

Site	Service	Comp #	Service Date	Last Internal Inspection	Availability of Spare	Comments
ANO2	Unit Aux	2X-02	3/26/80	Oct 2006	No spare	Contingency: use startup transformer; in this configuration susceptible to grid faults
ANO2	Startup	2X-03	3/26/80	~1999	No spare	Contingency: use startup transformer; in this configuration susceptible to grid faults
ANO1	Aux	X-02	12/19/74	~1997	No spare	Contingency: use startup transformer; in this configuration susceptible to grid faults
ANO1	Startup	X-03	12/19/74	~1997	No spare	Contingency: use startup transformer; in this configuration susceptible to grid faults
GGNS	Distribution	BOP13	1985	Never	No spare	Has contingency; no spare bushings
GGNS	Distribution	BOP11A	1985	Never	No spare	Has contingency; no spare bushings; HV and neutral on order
GGNS	Distribution	BOP11B	1985	1/2007	No spare	Has contingency; no spare bushings
GGNS	Main	Main Spare	1985		Is Spare	Needs to be refurbished; no current installation plan – spare has been used before.
GGNS	Distribution	BOP14	1985	Never	No spare	No contingency: Lose Aux cooling tower
GGNS	Service Transformer	ST11	1985	Never	No spare	No contingency; no spare bushings; LV and neutral on order; HV not currently on order – 34 wk lead time. AMP has item for replacement in 2009; needs cost updated.
GGNS	Distribution	ACT 1X191	2001	Never	No spare	No contingency; no parts
GGNS	Distribution	ACT 1X192	2001	Never	No spare	No contingency; no parts
GGNS	Distribution	BOP23	1985	Never	No spare	No contingency; no parts

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EN Large Power Transformer Status:

Table 2: Site Spare Transformer/Issues (cont)

Site	Service	Comp #	Service Date	Last Internal Inspection	Availability of Spare	Comments
GGNS	Service Transformer	ST21	1985	Never	No spare	No contingency; no spare bushings; LV and neutral on order; HV not currently on order – 34 week lead time. AMP has item for replacement in 2009; needs cost updated.
GGNS	Distribution	BOP12A	1985	Never	No spare	Has contingency; no spare bushings; HV and neutral on order
GGNS	Distribution	BOP12B	1985	Never	No spare	Has contingency; no spare bushings
IPEC	Gen Step Up	21MTRFR	5/19/2006	New	No spare	No contingency
IPEC	Gen Step Up	22MTRFR	5/19/2006	New	No spare	No contingency
IPEC	Unit Aux	UAT	1976	Never	No spare	No contingency: to be addressed in 2010 replacement program as per AMP
IPEC	Unit Aux	UAUX	1974	Never	No spare	No contingency: to be addressed in 2010 replacement program as per AMP
JAF	71T-1A	Gen Step Up	1974	1988	No spare	Contingency: use Pilgrim Spare (questionable); replace 2007-2008 on AMP
JAF	71T-1B	Gen Step Up	1974	1988	No spare	Contingency: use Pilgrim Spare (questionable); replace 2007-2008 on AMP
JAF	71T-2	Reserve	1974	Never	Spare Available	Contingency: use Spare; no installation plans
JAF	71T-3	Reserve	1974	Never	Spare Available	Contingency: use Spare; no installation plans
JAF	71T-4	Aux	1974	Never	No spare	Contingency: Can operate at 60% power w/o transformer
PNPS	X13	SDT	1969	Never	No spare	Contingency: available from industry on short notice; 2008-9 plan to install another transformer that can backup (AMP)
PNPS	X4	SUT	1969	Never	Spare Available	2008-9 plan to install another transformer that will be SUT with existing becoming an installed spare (AMP)
RBS	MTX-XM1	Gen Step Up	1985	2006	No spare	Based on recent study no spare to be purchased. (conflicts w/AMP)

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Table 2: Site Spare Transformer/Issues (cont)

Site	Service	Comp #	Service Date	Last Internal Inspection	Availability of Spare	Comments
RBS	MTX-XM2	Gen Step Up	1985	2004	No spare	Based on recent study no spare to be purchased. (conflicts w/AMP)
RBS	STX-XNS1A	Unit Aux	1985	2006	No spare	Contingency: use Reserve transformer; in this configuration susceptible to grid faults
RBS	STX-XNS1B	Unit Aux	1985	Never	No spare	Contingency: use Reserve transformer; in this configuration susceptible to grid faults
RBS	STX-XNS1C	Unit Aux	1985	Never	No spare	Contingency: use Reserve transformer; in this configuration susceptible to grid faults
VTY	T-1-1A	Gen Step Up	9/2002	new	Spare Available	Contingency plan: derate – spare rated at 650 MVA; spare currently not ready for use.
VTY	T-2-1A	Unit Aux	1972	unknown	No spare	AMP has 2008 expenditure for replacement in RF027; No cont: transformer lightly loaded; low risk of failure
VTY	T-3-1A	SUT	1976	unknown	No spare	AMP has 2010 expenditure for replacement in RF027; No cont: transformer lightly loaded; low risk of failure
VTY	T-3-1B	SUT	1976	unknown	No spare	AMP has 2011 expenditure for replacement in RF027; No cont: transformer lightly loaded; low risk of failure
WF3	MT EMT A	Main	5/1/2005	New	Spare Available	Contingency plan: Derate - Spare rated at 600MVA
WF3	MT EMT A	Main	5/1/2005	2005	Spare Available	Contingency plan: Derate - Spare rated at 600MVA
WF3	UATEMT A	Aux	~1978	~2001	No Spare	Contingency: use startup transformer; in this configuration susceptible to grid faults
WF3	UATEMT B	Aux	~1978	~2001	No Spare	Contingency: use startup transformer; in this configuration susceptible to grid faults

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