

JOB SAFETY ANALYSIS POWER TRANSFORMER TESTING



<i>Title:</i> Transformer Testing	
<i>Purpose and Scope:</i> The purpose of this SWP is to outline the requirement for performing these tests on out of service power transformers:	<ul style="list-style-type: none">• Ratio Test• Over-potential Test• Power Frequency Withstand Test• Load Loss Test• No Load Loss Test
<ul style="list-style-type: none">• Performing High Voltage Testing in the field• Power Transformer DC Resistance Test• Oil Sampling	
<i>Staffing Resources:</i> Persons holding a minimum qualification of electrical fitter with adequate training in this practice and apprentices, trainees or other staff while under direct supervision of qualified personnel.	
<i>Documentation/References:</i> <ul style="list-style-type: none">• Scope of works• Standard to which Transformer was designed. This SWP is based on:<ul style="list-style-type: none">– AS2374.1 – 1997, Power transformers - General– AS2374.3.0 – 1982, Power transformers – Insulation levels and dielectric tests – General requirements• Power Transformer Dielectric and Insulation Test Report form SP0504C01• Power Transformer Cold Winding Resistance Test Report form SP0504C02• Power Transformer No Load Ratio Test Report form SP0504C03• Power Transformer No Load Loss Test Report form SP0504C04• Power Transformer Load Loss Test Report form SP0504C05 and load loss calculation forms SP0504C06	<ul style="list-style-type: none">• Past test results if available• Instruction manual (Manufacturer's or local) for relevant<ul style="list-style-type: none">– Insulation Resistance test equipment.– DC Resistance test equipment– No Load Loss test equipment– Load Loss test equipment– Power Frequency Withstand test equipment– Over-potential Withstand test equipment– Ratio test equipment Scope of works

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<p><i>Key Tools and Equipment:</i></p> <ul style="list-style-type: none"> • PPE – Long sleeve shirt and long trousers, safety footwear, safety helmet, gloves and protective eyewear where signed. • Safety barriers and warning signs. • Shorting leads. • Time piece to record one to ten minute readings. • Insulation Resistance test equipment. • DC Resistance test equipment • Ratio test equipment. • Surface thermometer • Oil sample test equipment. • Oil spill kit • Test equipment will vary form site to site. 	<ul style="list-style-type: none"> • Load Loss test equipment. <ul style="list-style-type: none"> • Supply source capable of supplying at least 50% of winding Full Load Current (FLC), • DC Resistance equipment, • RMS Voltmeter, Measuring VTs, Ammeter, Metering CTs, Wattmeter, (These meters may be replaced by power analysers or other appropriate meters.) • Shorting bars capable of full rated current of the winding to be shorted • No Load Loss test equipment: <ul style="list-style-type: none"> • Voltage source capable of rated voltage of transformer under test, • Average and RMS Voltmeters, • Measuring VTs, Ammeters, Metering CTs, Wattmeter, (These meters may be replaced by power analysers or other appropriate meters). 	<ul style="list-style-type: none"> • Power Frequency Withstand test equipment including suitable single-phase test transformers of sufficient voltage and VA, voltage and current measuring equipment. <ul style="list-style-type: none"> • Ammeter with parallel spark gap • Measurement VT and voltage meter • Over-potential Withstand tests equipment including a three phase high frequency generator, three phase interposing test transformer, voltage and current measuring equipment – suitable for use at the test frequency. <ul style="list-style-type: none"> • Voltage meters to measure test voltage (with input impedance to match voltage divider). • Ammeters to measure the phase current.
Development Team: Phil Ives and Helena Tholsgard	Date Completed: 16 April 2003	
Reviewed By: Robert Bates	Date Completed: 27 September 2004	
Related SWP No.: SP0504	SWP Owner Approval: Neil Dwyer	
Key Stakeholders:		

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Task No.	Task Step	Hazard	Most Likely Breakdown Event (Loss Of Control)	Most Likely Outcome (Incident Outcome)	Risk Score	
					Existing Controls	Additional/Alternate Controls
1	Preliminary steps	Refer JSAs for Testing in the field and workshop				
2	Performing Insulation Resistance Testing	Test Voltage from Test Equipment Trapped Charges	Failure to keep persons clear of live test equipment Failure to discharge equipment under test	Electric Shock	Low	
3	Power Transformer Oil Sampling	Transformer oil, PCB Oil under pressure from head of oil	Spillage	Skin irritation, environmental harm	Low	
4	Power Transformer DC Resistance Test	High Electromagnetic Energy in charged windings	Leads removed from winding before discharge, high voltage spike from collapsing magnetic field	Electric Shock	Low	
5	Power Transformer Ratio Test	Live LV from auxiliary supplies Live LV from ratio test set High Voltage from CT secondaries	Inadvertent contact with LV in auxiliary supplies or from test set Open Circuited CT secondary windings, unearthed VT windings	Electric Shock Damage to equipment – CT secondary windings	Low	
6	Power Transformer Power	High Voltage from CT	Open Circuited CT secondary	Electric Shock	Low	

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Task No.	Task Step	Hazard	Most Likely Breakdown Event (Loss Of Control)	Most Likely Outcome (Incident Outcome)	Risk Score	
					Existing Controls	Additional/Alternate Controls
	Frequency Withstand Test	secondaries Floating VT voltages High Voltage from Test Set LV from input supply to Test Set	windings, unearthed VT windings Failure to isolate & earth transformer under test after test Inadvertent contact with LV supply leads Failure of leakage current ammeter HV Test voltage exceeds set point or control malfunction gives runaway Insufficient clearance between test HV leads and between test leads and other apparatus	Damage to equipment – • CT secondary windings • HV Test Set • Transformer under test		
7	Power Transformer Over-potential Test	High Voltage from CT secondaries Floating VT voltages High Voltage from Test Set LV from input supply to Test Set	Open Circuited CT secondary windings, unearthed VT windings Failure to isolate & earth transformer under test after test Inadvertent contact with LV supply leads HV Test voltage exceeds set point or control malfunction gives runaway Insufficient clearance between test HV leads and between test leads and other apparatus	Electric Shock Damage to equipment – • CT secondary windings • HV Test Set • Transformer under test	Low	
8	Power Transformer Load Loss Test	High Voltage from CT secondaries	Open Circuited CT secondary windings, unearthed VT windings	Electric Shock Damage to equipment –	Low	

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Task No.	Task Step	Hazard	Most Likely Breakdown Event (Loss Of Control)	Most Likely Outcome (Incident Outcome)	Risk Score	
					Existing Controls	Additional/Alternate Controls
		Floating VT voltages Applied Test Voltages Hot test leads and connections	Exceeding the current rating of the Test Equipment – use of incorrect CT tapings on measuring circuit Use of under rated shorting bars Failure to isolate & earth transformer under test after test Inadvertent contact with test supply leads Insufficient clearance between test HV leads and between test leads and other apparatus	<ul style="list-style-type: none"> • CT secondary windings • Test Set • Transformer under test 		
9	Power Transformer No Load Loss Test	High Voltage from CT secondaries Floating VT voltages Applied Test Voltages	Open Circuited CT secondary windings, unearthed VT windings Exceeding the rating of the Test Equipment – use of incorrect VT ratios on measuring circuit Failure to isolate & earth transformer under test after test Inadvertent contact with test supply leads Insufficient clearance between test HV leads and between test leads and other apparatus	Electric Shock Damage to equipment – <ul style="list-style-type: none"> • CT secondary windings • Test Set • Transformer under test 	Low	
10	Complete and Clean up	Undischarged or energised test equipment Energised HV apparatus without fault protection	Failure to isolate, discharge and earth all test equipment Failure to restore transformer under test to condition as delivered (such as shorted CTs)	Electric Shock Damage to equipment – <ul style="list-style-type: none"> • VT secondary windings • Transformer that was under test 	Low	

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Existing Control Measures

Task No.	Elimination	Substitution	Engineering	Administration	Personal Protective Equipment	Risk Ranking			
						C = Consequences	E = Exposure	P = Probability	Risk Score
1	Control measures are in place as described in the JSA "Carry Out Field Testing" SP0506R01 and it's related SWP SP0506 as well as the SWP "Power Transformer Testing" SP0504								
2					Standard PPE, fall restraint harness	2	4	4	Low
3					Standard PPE, Nitrile gloves and full face shield	1	4	4	Low
4						2	4	4	Low
5					Standard PPE	2	4	4	Low
6					Standard PPE	3	6	5	Low
7					Standard PPE,	3	6	5	Low
8					Standard PPE, leather gloves for hot test leads	2	6	5	Low
9					Standard PPE	2	6	5	Low
10					Standard PPE	2	4	4	Low

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Additional/Alternative Control Measures

Task No.	Elimination	Substitution	Engineering	Administration	Personal Protective Equipment	Risk Ranking			
						C = Consequences	E = Exposure	P = Probability	Risk Score

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1: DETERMINE CONSEQUENCE: - The most likely outcome of a potential incident resulting from exposure to the identified hazard.

Level	Descriptor	Definition
5	Disaster	Fatality; toxic release off-site with detrimental effect; financial loss (>\$1,000,000).
4	Very Serious	Extensive injuries (e.g. permanent disability, amputation) requiring medical treatment, hospitalisation and long term rehabilitation; off-site release with no detrimental effects loss of production capability; financial loss (\$500,000 to \$1,000,000).
3	Serious	Disabling injuries requiring medical treatment and rehabilitation (e.g. broken limbs, hospitalisation); on-site release contained with outside assistance; financial loss (\$50,000 to \$500,000).
2	Substantial	Medical treatment required (e.g. stitches, removal of foreign body); on-site release immediately contained; financial loss (\$5,000 to \$50,000).
1	Minor	First aid treatment; negligible environmental damage; financial loss (<\$5,000).

2: DETERMINE EXPOSURE: - How often a person interacts with a hazard.

Level	Descriptor	Definition
1	Continuous	Many times a day.
2	Frequent	Daily.
3	Occasional	Weekly.
4	Infrequent	Between weekly and monthly.
5	Rare	Between monthly and yearly.
6	Very Rare	Less than once a year.

3: DETERMINE PROBABILITY

The likelihood of the breakdown event and nominated consequences occurring once the person is exposed to the hazard.

Level	Descriptor	Definition
1	Almost Certain	Breakdown event will almost certainly occur from exposure to hazard.
2	Quite Possible	Not unusual for breakdown event occurring, even 50/50 chance.
3	Unusual but Possible	Unusual for breakdown event to occur but possible.
4	Remotely Possible	Remote possibility of breakdown event occurring but history of occurrence exists within industry.
5	Conceivable but Unlikely	No known history of breakdown event occurring after years of exposure but is conceivably possible.
6	Practically Impossible	Practically impossible for breakdown event to occur. Has never occurred before and is not likely to occur.

4: RISK ASSESSMENT MATRIX

Consequences (How Bad?)	Probability x Exposure				
	1 to 2	3 to 5	6 to 10	11 to 23	24 to 36
	Likelihood (How often?)				
	Almost certain will occur	Quite possible could occur	Possible	Unlikely but possible	Extremely unlikely
5. Disaster	Extreme	Extreme	Extreme	High	Moderate
4. Very Serious	Extreme	Extreme	High	Moderate	Low
3. Serious	Extreme	High	High	Moderate	Low
2. Substantial	High	Moderate	Moderate	Low	Low
1. Minor	High	Moderate	Low	Low	Low

5: RISK TREATMENT STRATEGY

Risk Score	Required Actions
Low	Implement control measures and verify compliance by routine monitoring.
Moderate	Action required within agreed timeframe to minimise risk to "As Low As Reasonably Practicable" (ALARP). Further action may be required and management responsibility specified to take this action. The ALARP principle implies that controls have been determined such that the level of risk-reducing action is in proportion to the benefit obtained.
High	Action as soon as possible to minimise risk to acceptable level. Requires attention by senior management and measures should be put in place to reduce the probability, exposure and/or consequence of the outcome occurring to ALARP.
Extreme	Same treatment as for high risks however immediate action required to minimise risk to acceptable level.

(Adapted from AS/NZS 4360:1999 Risk Management and NSCA Risk Score Calculator, 2001)