PACIFICORP
A MIDAMERICAN ENERGY HOLDINGS COMPANY

SPECIFICATION

TWO-WINDING DISTRIBUTION TRANSFORMER

INVERTER STEP-UP LIQUID-IMMERSED

(PAD MOUNTED, COMPARTMENTAL TYPE)

ZS-102

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2	04/04/2016	Revised for use with PV and Wind Farms. – J. Bohrn
3		
4		

Scope

This material specification states the requirements for two winding, three phase, liquid-immersed, step-up distribution outdoor transformers (pad-mounted, compartmental type) for use on the output of low voltage utility grade inverters.

References

The following publications shall be used in conjunction with this material specification, and form a part of this material specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision shall apply.

Industry Publications

Referenced industry publications are:

IEEE P60076-16, Wind Turbine Generator Transformer Standard

IEEE C37.74, Standard Requirements for Subsurface, Vault, and Padmounted Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV

IEEE C57.12.00, Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.12.10, Standard Requirements for Liquid-Immersed Power Transformers

IEEE C57.12.28, Standard for Padmounted Equipment Enclosure Integrity

IEEE C57.12.29, Standard for Padmounted Equipment Enclosure Integrity for Coastal Environments

IEEE C57.12.34, Standard Requirements for Padmounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below

IEEE C57.12.35, Standard for Barcoding for Distribution Transformers and Step-Voltage Regulators

IEEE C57.12.70, Standard Terminal Markings and Connections for Distribution and Power Transformers

IEEE 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V DOE 10 CFR Part 431, Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation; Final Rule

Company Publications

Applicable MidAmerican Energy / PacifiCorp documents may include, but shall not necessarily be limited to, those listed below:

Material Specification 510–1 / ZS 061, Electrical Equipment—Insulating Oil

Material Specification 210–1 / ZS 065, Wind, Ice, and Seismic Withstand

Material Specification 210–2 / ZS 066, Contaminated-Environment Protection
PacifiCorp Procedure SP–TRF–INST, Transformer Receiving, Installation and Energizing
PacifiCorp Design Review Data Sheets (revision 4, dated December 23, 2009)
PacifiCorp Engineering Form 006F, Meter and Relay Equipment Memorandum
PacifiCorp Specification ZG 532, *Flat Pad — Three-Phase Transformer*
Company Specification ZG 113/12–4000, *Signage, Padmounted Electrical Equipment*

General

This specification includes approximate metric conversions of American units and gauges that are for guidance only; the American standard shall take precedence. Transformers shall be designed to withstand geomagnetic disturbances per NERC requirements.

Except as required otherwise by this Material Specification the transformer and individual components shall be furnished in accordance with the latest applicable industry codes and standards.

Company: Refers to PacifiCorp, Pacific Power, Rocky Mountain Power and MidAmerican Energy Company.

Ratings

Table 1 through 3 provide the standard voltage and kVA ratings

Table 1
Transformer Ratings and Electrical Characteristics

Transformer		
	Basic Impulse Insulation Level – BIL (kV)	
Voltage Ratings (volts)	Distribution Transformers	Power Transformers
Low Voltage Ratings (V) 208Y/120 480Y/277 690Y/398 _____ Other Voltage	30	45
High Voltage Ratings (V)		
4160GrdY/2400	60	75
8320GrdY/4800	75	95
12470GrdY/7200	95	110
13200GrdY/7620	95	110
13800GrdY/7970	95	110
22860GrdY/13200	125	150
23900GrdY/13800	125	150
24940GrdY/14400	125	150
34500GrdY/19920	150	200
43800GrdY/25300	-	250

** Note – The above table is not meant to list every voltage available

1.1 The secondary voltage shall be one of the above from Table 1.

- For a Secondary Unit Substation Transformer (Secondary voltage below 1000 V):
- The secondary voltage and the basic impulse insulation level (BIL) shall be in accordance with the secondary voltages listed in Table 1 and shall be specified on the data sheet.

1.2 The transformer shall either be furnished with a grounded Wye primary winding (HV winding) or a separate grounding transformer (Grounded Wye primary / Delta secondary) shall be provided for connection on the station side of the breaker.

1.3 The transformer shall be furnished with four~~Six~~ (4~~6~~) 2.5 percent taps, two~~four~~ (2~~4~~) above and two (2) below, full capacity high-voltage taps; with externally operable five~~seven~~ (5~~7~~) position tap changer for de-energized use and with position indicator and padlock hasp. The tap-changer shall be clearly labeled to reflect that the transformer must be de-energized before operating the tap-changer as required in Section 4.3 of ANSI C57.12.34.

~~**1.4** The dielectric coolant shall be listed less-flammable fluid meeting the requirements of National Electrical Code Section 450-23 and the requirements of the National Electrical Safety Code (IEEE C2-2002), Section 15. The dielectric coolant shall be non-toxic*, non-bioaccumulating and be readily and completely biodegradable per EPA~~

~~OPPTS 835.3100. The base fluid shall be 100% derived from edible seed oils and food grade performance enhancing additives. The fluid shall not require genetically altered seeds for its base oil. The fluid shall result in zero mortality when tested on trout fry *. The fluid shall be certified to comply with the US EPA Environmental Technology Verification (ETV) requirements, and tested for compatibility with transformer components. The fluid shall be Factory Mutual Approved, UL Classified Dielectric Medium (UL-EOUV) and UL Classified Transformer Fluid (UL-EOVK), Envirotemp™ FR3™ fluid. *(Per OECD G.L. 203)~~

~~1.5~~1.4 The transformer, filled with ~~Envirotemp™ FR3™~~ fluid, shall have a 65 °C average winding temperature rise rating. The above winding temperature rise shall not exceed 65 °C when loaded at base kVA rating

~~1.6~~1.5 The percent impedance voltage, as measured on the rated voltage connection, shall be per ANSI C57.12.10.

~~1.7~~1.6 The transformer shall be cooled by the natural circulation of air over the tank surface and any corrugate or radiators if required, allowing only the base kVA rating shall be provided with Class O~~K~~NAN.

Construction

~~1.8~~1.7 The core and coil shall be vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system. While under vacuum, the windings will be energized to heat the coils and drive out moisture, and the transformer will be filled with preheated filtered degassed insulating fluid. The core shall be manufactured from burr-free, grain-oriented silicon steel and shall be precisely stacked to eliminate gaps in the corner joints. The coil shall be insulated with B-stage, epoxy coated, diamond pattern, insulating paper, which shall be thermally cured under pressure to ensure proper bonding of conductor and paper.

~~1.9~~1.8 Panel type radiators or corrugate type cooling are welded directly to the tank when additional cooling is required.

~~1.10~~1.9 In addition to the requirements of IEEE C57.12.29, transformer component materials shall be as described below, or shall be company approved equivalents.

- Transformer tank, enclosure and control panel components shall be 304-L stainless steel.
- All welds shall be continuous. Spot or skip welds are not acceptable.
- Ground pads shall be 300-series stainless steel, copper, or bronze.
- All bolts, washers, hinges and door lifting provisions shall be 300-series stainless steel or silicon bronze. Compatible metals shall be used to prevent galling.

~~1.11~~1.10 The tank shall be welded using precision cut, cold-rolled steel plate and equipped with extra-heavy duty, welded-in-place lifting lugs and jacking pads. The tank base shall be designed to allow skidding or rolling in any direction.

~~1.12~~1.11 The transformer shall be of sealed tank construction of sufficient strength to withstand a pressure of 7 psig without permanent distortion, and 15 psig without rupturing.

~~1.13~~1.12 The tank shall include a pressure relief device as a means to relieve pressure in excess of pressure resulting from normal operation. The venting and sealing characteristics shall be as follows:

Cracking Pressure: 10 psig +/-2 psig
Resealing Pressure: 6-psig minimum
Zero leakage from reseal pressure to -8 psig
Flow at 15 psig: 35 SCFM minimum

~~1.14~~1.13 The exterior color shall be Munsell Green~~BLM Carlsbad Canyon~~.

~~1.15~~1.14 The tank shall be cleaned with an alkaline cleaning agent to remove grease and oil. An iron phosphate coating shall then be chemically bonded to the metal to assure coating adhesion and retard corrosion. The tank shall be primed with an electrodeposited powder epoxy to provide a barrier against moisture, salt, and corrosives. The tank shall then be coated with an electrostatically-applied, oven-cured polyester powder coat to enhance abrasion and impact resistance. The top-coat shall be a liquid polyurethane coating to seal and add ultraviolet protection. The tank coating shall meet all requirements in IEEE C57.12.28 – latest revision.

~~1.16~~1.15 The tank shall be complete with an anodized aluminum laser engraved nameplate. This nameplate shall meet IEEE C57.12.25.

~~1.17~~1.16 The transformer nameplate shall contain a company assigned ID (Equipment Number), Project Number, and Date of Mfr.~~.~~ It shall also contain all applicable weights, volumes, voltages, impedances, cautions, warnings, winding configurations, cooling information, and anything else that may be helpful when performing maintenance and troubleshooting.

~~1.18~~1.17 A duplicate stainless steel nameplate shall be affixed to the exterior of the transformer. The duplicate nameplate shall remain intact and legible for the life of the equipment.

~~1.19~~1.18 The transformer's warranty duration or expiration date shall be provided on the transformer nameplate or on a separate nameplate or signage permanently affixed to the interior termination compartment for the transformer.

~~1.20~~1.19 The overload sensing fuse type for each high voltage rating specified shall be listed on the nameplate.

~~1.21~~1.20 Bushings shall be replaceable externally or access shall be provided through a hand-hole. To facilitate field replacement bushings shall be externally secured to the transformer tank.

~~1.22~~1.21 Bushings shall be marked in accordance with IEEE C57.12.00

~~1.23~~1.22 High Voltage Bushings and Terminals

- High voltage terminals shall utilize 200A loadbreak bushings, bushing wells, and bushing inserts complying with IEEE 386. They shall be radial fed and in compliance with IEEE C57.12.18. The high voltage bushings shall be mounted in Segment 2, Segment 3, or Segment 4 of the transformer.

~~1.24~~1.23 Low Voltage Bushings and Terminals

- Low voltage line and neutral terminals shall be a staggered arrangement as specified by Figure 4(a) of IEEE C57.12.34. Terminal supports and the neutral bushing grounding strap shall not interfere with the use of terminal spade positions. Bracing shall be provided on secondary with eight or more hole positions.

~~1.25~~1.24 The low voltage line and neutral terminals shall be 10 hole NEMA spade terminals.

~~1.26~~1.25 Overcurrent Protection and Switching

- The high-voltage overcurrent protection scheme provided with the transformer shall be a loadbreak Bay-O-Net assembly with a flapper valve to minimize oil spillage. Overcurrent protection shall be provided by a Bay-O-Net expulsion fuse mounted in series with partial range under-oil ELSP current-limiting fuses with an interrupting rating of 30,000 A.

Finish Performance Requirements

~~1.27~~1.26 The tank coating shall meet all requirements in ANSI C57.12.28 including:

- Salt Spray
- Crosshatch adhesion
- Humidity
- Impact
- Oil resistance
- Ultraviolet accelerated weathering
- Abrasion resistance – taber abraser

Production Testing

1.27 All ~~units shall be tested for the following~~units shall have routine tests performed as specified in IEEE C57.12.90 and IEEE C57.150 (core ground test):

1.28 In addition, all units shall be tested for the following:

~~1.28~~

- No-Load (85 °C or 20 °C) losses at rated current, 110% rated voltage
- Total (85 °C) losses at rated current
- Percent Impedance (85 °C) at rated current
- Excitation current (110% voltage) test
- Winding resistance measurement tests

- Ratio tests using all tap settings
- Polarity and phase relation tests
- Induced potential tests
- Full wave and reduced wave impulse test

1.29 Minimally, transformers shall conform to efficiency levels for liquid immersed distribution transformers, as specified in Table I.1 of the Department of Energy ruling. "10 CFR Part 431 Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule; October 12, 2007." Manufacturer shall comply with the intent of all regulations set forth in noted ruling. This efficiency standard does not apply to step-up transformers.

1.30 In addition, the manufacturer shall provide certification upon request for all design and other tests listed in C57.12.00, including verification that the design has passed short circuit criteria per ANSI C57.12.00 and C57.12.90.

1.31 The manufacturer shall furnish specifications for coordinated current limiting fuses and isolation links for each transformer design.

1.32 The manufacturer shall furnish copies of routine tests in conformance with IEEE C57.12.25 representative designs proposed to be supplied to the company. Copies of routine production tests for transformers purchased by the company shall be made available upon request.

1.33 The manufacturer shall furnish detailed drawings clearly depicting the compatibility between the transformer, mounting hardware, and specified equipment bases.

1.34 The manufacturer shall furnish certified test reports showing transformer designs compliant with this Material Specification are compliant with IEEE C57.12.28 and IEEE C57.12.29.

1.35 The manufacturer shall furnish drawings showing physical dimensions of assembled transformers and all user accessible components, markings and labels.

1.36 The manufacturer shall furnish instruction manuals that cover receiving, handling, installation, operation and maintenance of the transformers.

1.37 The manufacturer shall furnish complete lists of renewal parts for the transformers, including identification of each part by name and part number. Parts Lists and drawings shall relate specifically to the equipment covered by this specification.

1.38 The manufacturer shall furnish an exceptions report itemizing all exceptions or nonconformance with this Material Specification. Bids submitted without exception shall indicate "No Exceptions" on the exceptions report.

Accessories

The following standard accessories and options shall be provided:

- De-energized Tap-Changer
- 1.0" Upper Fill Plug with Filter Press Connection

- 1.0" Drain/Sampling Valve
- Cover-Mounted Automatic Pressure Relief Device
- Welded Cover with Bolted Manhole
- Lifting Lugs (4)
- Liquid Level Gauge
- Dial Type Thermometer
- Pressure/Vacuum Gauge
- SS Ground Pads (4)

Optional Accessories

The following optional accessories and options shall be provided if specified:

[ ] Low Voltage 6-Hole Spade
[ ] Low Voltage 12-Hole Spade
[ ] Copper Low Voltage Bushings (standard with all-copper windings)
[ ] Bleeder Valve (Standard on 2500 kVA and above)
[ ] Nitrogen Blanket with Bleeder and Purge Valve
[ ] Touch-up Paint (aerosol cans)
[ ] NEMA 4 Control Box (standard with forced air fan cooling package and required for auxillary contacts or rapid rise relay)
[ ] NEMA 4X Control Box (stainless steel)
[ ] NEMA 7 Control Box (explosion proof)
[ ] Rapid Pressure Rise Relay
[ ] Seal-In Panel for Rapid Pressure Rise Relay
[ ] Forced Air Fan Control Package
[ ] Winding Temperature Indicator
[ ] Auxiliary Contacts for Liquid Level Gauge
[ ] Auxiliary Contacts for Dial Type Thermometer (standard with fan package)
[ ] Auxiliary Contacts for Pressure/Vacuum Gauge
[ ] Auxiliary Contacts for Pressure Relief Device
[ ] Globe Type Upper Fill Valve

Special Features

1.39 The following special features shall be provided if specified:

[ ] All Copper Windings
[ ] Primary Air Disconnect Switch
    [ ] 1200 A Loadbreak Rating (requires 1200 A copper bus bar)
    [ ] Outer Front Door (covers viewing area and switch)
    [ ] Key Interlocks for interlocking switch with secondary
    [ ] Porcelain Bus Insulators
    [ ] Copper Bus Transition to Transformer (required for 600 A and greater)
    [ ] Auxiliary Switch (remote indication of primary switch position)
    [ ] Line-side Bus (bottom entry only)
    [ ] Thermostat for Space Heater
[ ] Vacuum Fault Interrupter, 600 A Continuous, 12000 A RMS Interrupting
[ ] Dead Front HV Termination

[ ] Loop Feed
[ ] Radial Feed

[ ] Stainless Steel Cabinet
[ ] Tank Base
[ ] Primary Enclosure
[ ] Secondary Enclosure

[ ] Cooling
[ ] Mild Steel Radiators
[ ] Welded
[ ] Removable
[ ] Stainless Steel Radiators
[ ] Welded
[ ] Removable
[ ] Galvanized Steel Radiators (removable and unpainted)

[ ] K-Factor Transformer

[ ] Positive Nitrogen Pressure Oil Preservation System

[ ] Current Transformers for Relaying/Metering

[ ] Containment Pan for indoor use for 100% fluid containment

[ ] Factory Mutual (FM) Approved transformer (for NEC Code-listed installations on, near, or inside of buildings)

[ ] UL Listed and Classified transformer (for NEC Code-listed installations on, near, or inside of buildings) per UL XPLH

[ ] UL Listed transformer (certifying compliance with ANSI standards only) per UL XPLH

Shipping

1.40 Transformers shall be loaded and unloaded with overhead cranes.

Data with Proposal

1.41 The following data shall be submitted with the proposal:

- Core losses (when requested per Sections 6.4 and 11.0).
- Winding losses (when requested per Sections 6.4 and 11.0).
- Percent Impedance
- Typical bid drawing

1.42 The following checked data shall be submitted with the proposal:

[ ] Exciting Current @ 100% and 110% rated Voltage.
[ ] Efficiencies must be provided at loading levels of 100%, 75%, 50%, and 25%.
[ ] Percent regulation must be provided at 0.8 PF and 1.0 PF.

Drawings

1.43 The following will be provided by request after receipt of order:

[ ] Construction Drawings
[ ] Record Drawings
[ ] Approval Drawings
[ ] CAD Drawings on diskette
[ ] CD available upon request

TRANSFORMER DATA SHEET 112.5-10000 kVA
THREE-PHASE UNIT SUBSTATION DISTRIBUTION TRANSFORMER

In the case of contradictory specifications, this Data Sheet takes precedence over the Specification.

ITEM_____OF_____
Scope: [X] Outdoor
[ ] Outdoor, on or adjacent to building

[ ] Indoor
kVA:_____ [ ] 60 Hz [ ] 50 Hz
Temperature Rise: [X] 65 °C
[ ] 75 °C
[ ] 55/65 °C
[ ] 55/75 °C (KNAN only)
Special Altitude: _6000___ft (m)
Cooling Class: [X] ONAN ~~(KNAN)~~
[ ] ONAN/ONAF ~~(KNAN/KNAF)~~ 15% or 25% Capacity
[ ] ONAN/ONAF ~~(KNAN/KNAF)~~ 33% Capacity
[ ] ONAN/ONAF (Future) ~~(KNAN/KNAF (Future))~~
Liquid Type: [~~X~~] Envirotemp™ FR3™ Fluid
[X~~-~~] Oil
Primary Voltage: _~~12470~~_____ϕ-ϕ V BIL: __~~95~~____kV [ ] Aluminum [X] Copper
Connection: [ ] Delta - Wye
[ ] Delta - Delta
[~~X~~] Delta - Grounded Wye
[ ] Grounded Wye - Delta
[ ] Grounded Wye - Grounded Wye
[ ] Grounded Wye - Wye
Primary Taps: [ ] None
[ ] 2 @ +/-21/2%
[ ] 4 @ - 21/2%
[ ] NEMA Taps
[ ] Other: _____
Secondary Voltage: _____ϕ-ϕ V BIL: _____kV [ ] Aluminum [ ] Copper
Impedance: __~~5.75~~_____ [ ] ANSI Standard [ ] Minimum [ ] Maximum [ ]+/-7.5% Tolerance
Loss Evaluation: [ ] Efficiency per DOE (10CFR Pat 431)
[ ] Dollars/Watt (No Load): _____
[ ] Dollars/Watt (Load): _____
Primary Location: Cover-Mounted
[ ] Segment 2 [ ] Segment 3 [ ] Segment 4
Primary Bushings: [ ] Eyebolts
[ ] 2-Hole Spade
[ ] TBI Style Bushings
Secondary Location: Cover-Mounted
[ ] Segment 1 [ ] Segment 2 [ ] Segment 4
Secondary Bushings: [ ] Eyebolts
[ ] 2-Hole Spade
[ ] 6-Hole Spade
[ ] 12-Hole Spade

[ ] TBI Style Bushings

Primary Overcurrent Protection:

[ ] Vacuum Fault Interrupter

Time Current Curve: [ ] EF [ ] TF [ ] KF [ ] F [ ] H

[ ] TPG Control

[ ] TPG Control w/SCADA

[ ] IDEA iDp-210 Feeder Protection Relay (Cooper Power Systems)

Arresters: [ ] Heavy Duty MOV Distribution-Class Arrester

[ ] MOV Intermediate-Class Arrester

[ ] Station-Class Arrester

[ ] Arrester Mounting Provisions

Arrester Duty Cycle Rating: _____kV

Optional Accessories:

[ ] Copper Low Voltage Bushings (standard with all-copper windings)

[ ] Bleeder Valve (standard on 2500 kVA and above)

[ ] Nitrogen Blanket with Bleeder and Purge Valve

[ ] NEMA 4 Control Box (standard with forced air fan cooling package and required for auxiliary contacts or rapid rise relay)

[ ] NEMA 4X Control Box (stainless steel)

[ ] NEMA 7 Control Box (explosion proof)

[ ] Rapid Pressure Rise Relay

[ ] Seal-In Panel for Rapid Pressure Rise Relay

[ ] 120 Vac [ ] 240 Vac [ ] 24 VDC [ ] 48 VDC [ ] 125 VDC

[ ] Forced Air Fan Control Package

[ ] Winding Temperature Indicator

[ ] Auxiliary Contacts

[ ] Liquid Level Gauge

[ ] Dial Type Thermometer (standard with fan package)

[ ] Pressure/Vacuum Gauge

[ ] Pressure Relief Device

[ ] Globe Type Upper Fill Valve

[ ] Touch-up Paint (aerosol cans)

Special Features: [ ] Stainless Steel Cabinet

[ ] Tank Base

[ ] Primary Enclosure

[ ] Secondary Enclosure

[ ] Cooling

[ ] Mild Steel Radiators

[ ] Welded

[ ] Removable

[ ] Stainless Steel Radiators

[ ] Welded
[ ] Removable
[ ] Galvanized Steel Radiators (removable and unpainted)
[ ] Positive Nitrogen Pressure Oil Preservation System
[ ] K Rated Transformer [ ] K4 [ ] K9 [ ] K13 [ ] K20
[ ] Current Transformers [ ] Relaying [ ] Metering
Quantity___ Bushing_____ Ratio_____ Accuracy Class___
[ ] IDEA iXP-420 Differential Protection Relay (Select appropriate Current Transformers for Application)

Colors: [ ] ANSI #61 Light Gray
[ ] ANSI #70 Sky Gray
[ ] Standard Munsell No. 7GY3.29/1.5 Green
[ ] ANSI #24 Dark Blue Gray
[ ] ANSI # 49 Medium Gray
[ ] Other: _____

Testing: [ ] Routine (ANSI Standard)
[ ] Special: _____
_____
_____
[ ] Certified Test Results

Drawings: [ ] Approval
[ ] Record
[ ] CAD Drawings on CD

Mail Drawings To:
_____
_____
_____
Attn.: _____

Required Documentation

Completed Test Form PCF- RLY-MAINT-XFMR – Transformer and Reactor Relay Package Maintenance

Completed Test Form PCF-RLY-INSRVC – In Service Load Check Form