Power Transformers

An Xcel Energy Perspective
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Transformers – Why Worry?

XEL started taking a more involved approach to specifying/designing/inspecting/testing in the early 1990s

► Large Investment
  ► Large capital dollars
  ► Large installation/maintenance costs
  ► Large investment in time
  ► Single point-of-failure with extensive impact
Transformers – Why Worry?

► Opportunity for Error
  ► Highly engineered, customized product
  ► Special materials/processes
  ► Manual labor
  ► Accelerated production schedules
  ► Transportation challenges
Outline

► Specification
► Evaluation
► Design Reviews
► Drawings
► Inspections
► Witness Testing
► Field Receipt, Acceptance,
Specification

Companywide specification developed

► Combined specification
► Separate specification detail sheet and boilerplate
  ► Detail sheet
    ► EXCEL macro/formula tools
    ► Key ratings and project specific information in one location
Transformer Detail Sheet

This Detail Sheet shall be used in conjunction with XEL-STD-SPECIFICATION FOR PROCUREMENT OF POWER TRANSFORMERS AND REACTORS, Version 4.0 and governing Standards listed therein. In instances of conflicting information between the Detail Sheet and the Standard, the Detail Sheet shall take precedence.

Transformer Classification: Transmission Transformer
Winding Configuration: Autotransformer
Elevation: 3-Phase, 50 Hz

Rating: ONAN/ONANAFONAF 65C

Nominal Voltage (kV):
- HV: 161.00
- LV: 70.60
- TV: 13.80

Winding/Insulation:
- HV: 165.580 kV
- LV: 350 kV
- TV: 110 kV
- HX0: 150 kV

Bushing/External BIL:
- HV: 750 kV
- LV: 350 kV
- TV: 200 kV
- HX0: 200 kV

Minimum Bushing/External BIL Rating (Amperes):
- HV: 700
- LV: 1500
- TV: 900

NOTES:
- 1. When TV bushing BIL shall match.

QETC Positions: 5
De-Energized HV Taps:
- 198.500 kV
- 195.580 kV
- 181.000 kV
- 166.750 kV
- 152.200 kV

Impedance:
- HV - LV: 6.7 % on ONAN rating
- LTC: Required
- ± 30 % LTC

Oil preservation System:
- Conservator Design

Sound Level:
- 70 dBA No-Load w/No Isolation Cooling

Neutral Grounding Reactor: Not Required

TR shall be suitable for parallel operation with: Similar transformers

Surge Arresters:
- HV: 108.0 kV MCOV
- LV: 48.0 kV MCOV
- TV: 16.3 kV MCOV

Losses:
- $...kW No-Load at 100% voltage rating
- $...kW Load at 85% (40% ONAN losses)
- $...kW Auxiliary, second stage cooling rating

Location:
- CT Requirements: (A) 2.0 CT
- TRF: 2.0
- Accuracy: C600 MR

Control Voltage: 43 & 125 VDC
DC shall be capable of operation at other settings and shall initially be set for 125 VDC Temp. Indications: Electronic Type, Stake Section 4.0.8.0 and Exhibit A

Gas Monitor Device: Provides for future mounting only

RPRR Seal in relay: Not required

LTC Control Devices: Exhibit A & B, Option 1, Voltage Back-up Relay only

Quantity: 2
Location: Tremblal Substation

Delivery Date:  

Drawing Coordinator:
- Substation Engineering & Design
- Vendor Drawing Coordinator
- Kent Energy

OptCo OSPW
- Minneapolis, MN 55401
Specification

► Boilerplate – common design requirements
  ▶ Standards
  ▶ Overload
  ▶ Environmental
  ▶ Materials
  ▶ Testing
  ▶ Documentation
  ▶ Shipping
  ▶ Warranty
Evaluation

► Bid Data sheet
► Evaluation spreadsheet
  ► Check against spec rating requirements
  ► Comparison of proposals
  ► Losses
  ► Dimensions
  ► Type
  ► Lead time/ plant location
  ► Warranty
Design Reviews

► New/complicated design/multiple units
► First unit with a new supplier
► Preferably held at the factory
► Normally 1 to 1 ½ days
► Very detailed - NOT a specification review
Design Reviews

► Exceptions to specification
► Nameplate/preliminary outline
► Detailed factory test instructions
► Core design
► Winding design/arrangement
Design Reviews
► Major Insulation
► Thermal design
► Short-circuit design
► Ancillary component ratings
► Transportation strength (G-forces)
Drawings
- Nameplate(s)
- Outlines (Main and Shipping)
- Internal Assembly
- Controls
- Instruction Manual
- Factory Test Report & Data Files
- Photos of internal assembly and completely assembled unit
Drawings - Nameplate

► Ratings

LOAD-TAP-CHANGING TRANSFORMER

S/N: [Blank]
XEL EQUIPMENT ID: [Blank]
HV  450 kV BIL  550 kV BIL  118000 VOLTS
LV  150 kV BIL  200 kV BIL  2500 GNDY / 14430 VOLTS
NEUTRAL  150 kV BIL  200 kV BIL
CONT. TEMP. RISE  65°C HV / LV
IMPEDANCE  % AT  30 / 40 / 50 MVA @ 1000 M

THREE PHASE  60 Hertz
PHASE RELATIONSHIP  Dyn1
TESTED SOUND LEVEL
ONAN [Blank] dB
ONAF [Blank] dB
ONAF [Blank] dB

ALL WINDINGS ARE COPPER WOUND

► Other Info

- Notes
- Stnds References
Drawings - Nameplate

► Winding Diagram

- Check against phasor
- BCT ratings/location
- Polarities
- Core grounds
- Tap connections
Drawings - Outline

- All 4 segments & top view
- DIMs to proposal -within ~10%?
- Component Locations/Accessibility
  - Bushings
  - Cooling/fan staging
  - Control Cab
  - Conservator
- List of components
  - Manuf
  - Part/Cat # & Part #
Drawings – Internal Assembly

- Should show all 4 segments and top view
- Lead Routing/Support/Cooling
- Labeling/Location/Polarity of internal CTs
- Labeling of PA & Series TRs
- Dashed in location of access ports
Key Inspection Points

► Initial factory inspection – pre-award or during design review meeting
► Windings – prior to or during nesting
Key Inspection Points

- Core
- Core and coil assembly – before or after vapor phase
Witness Testing

► First or critical unit with supplier
  ► Builds confidence with compliance to specification
  ► Understand testing philosophy and methods

► Allows inspection of assembled unit
  ► Conduit routing interferences
  ► Components as indicated on drawings?

► Training Opportunity
Field Receipt, Inspection, Acceptance Process

► Supplier Releases

► SR1

► Review of impact recorder

► receipt core insulation resistance

► external inspection for damage

Verifies no obvious issues before receipting
Field Receipt, Inspection, Acceptance Process

► SR2

► Checklists/sign-off process

► Identifies responsibilities

► Determine need for internal inspections and guidance on items to inspect

► Identifies required field tests, tap settings, etc.

► Provides field testing acceptance criteria
Field Receipt, Inspection, Acceptance Process

► SR2

► Supplier review/sign-off of field test

► Engineering review/acceptance

Approval to energize or release for storage
Summary

► Develop a strong specification
  ► Living document

► Follow through (when appropriate) with:
  ► Design reviews
  ► Factory inspections
  ► Witness testing
  ► Field inspection & testing

► Develop checklists