March 18, 2021

CEA INSS

Transformer Relocation Plan

(FOR REFERENCE ONLY)

Introduction:

The following plan details the move of two 125-MVA transformers at the International Substation. These transformers will be rolled approximately 50 feet to new foundations. Construction of these foundations is currently underway. Transformer orientation does not change.

The plan is broken into six (6) parts:

- Pre-move Electrical Activity
- Pre-move Civil/Mechanical Activity
- Disassembly
- Relocation
- Assembly
- Quality and Acceptance Test

Pre-move Electrical Activity:

Introduction

Transformers can be damaged or contaminated when moved. This activity is focused on benchmarking the current condition of the transformer and prepping all auxiliary equipment needed to ensure the handling and processing of electrical insulating materials is of the highest quality.

Goals

- Validate current transformer condition
- Identify specialized materials needed that need to be obtained
- Identify specialized tools
- Elevate safety awareness

Risks

The major risks associated with performing these electrical planning and benchmarking tasks and achieving acceptable outcomes are:

- Oil/insulation found to be wet
- HV Bushings deteriorated
- Winding movement detected
- Missing covers and/or no replacement gaskets
- Excessive lead time on specialized materials
- Missing accessories
- Through-fault damage revealed
- Oil processing equipment not fully functional

Specialized Equipment

To complete these tasks, in addition to normal tools used by Substation Operating personal, the following tools are required:

- Insulation Power Factor Test Set
- SFRA Test Set

Main Tasks and Responsibilities

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
DGA Test	Validate there is no incipient fault prior to the move.	Failure in progress	Determine source Correct on-site Possibly plan for early replacement	Substation Operations
Oil Quality Test	Determine insulation current moisture content	High water content • Actual • Sample error • Lab error	Extra vacuum processing time to dry core and coils Re-sample and re-test	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
PF Test-Winding	Identify potential winding moisture problem	High PF or exciting current	Correlate with other tests Extra vacuum processing time	Substation Operations
Excitation Test-Windings	Identify potential winding movement	High exciting current	Correlate with other tests	Substation Operations
PF Test-Bushings	Identify deteriorated HV bushings. *Note GE type U bushings are planned to be replaced as part of this project.*	High PF or capacitance change	Replace bushing	Substation Operations
SFRA Test	Determine if the coil assembly has experienced excessive through fault forces Set a baseline for determining if the moving process exposed the coils to excessive acceleration/de-acceleration forces.	Excessive movement detected	Visually inspect Possibly plan for early replacement	Substation Operations
HV Bushing Cover Plates	Locate OEM bushing cover plates, clean, and place in a suitable storage location.	Cover plates are missing	Manufacture temporary plates	Substation Operations
HV Bushing Storage	Locate bushing crates or stands. ***Note: Bushings are not allowed to be stored horizontally (20º angle min); the glass sight gauge must be higher than the corona ring on the lower portion of the bushing.*** ***HV bushings are to be replaced.***	Bushing crates are not available	Build crates or find stands that are of a suitable height that provide adequate protection.	Substation Operations
LV Arrester Removal	Determine if the LV Arresters are to be removed before the transformer move. *Note: LV Arresters are to be removed*	LV arresters are not removed but are later identified as an obstacle.	Remove at a later time.	Substation Operations
Radiator Removal	Determine if the radiators contain valves and drain plugs to facilitate isolated draining of the oil	No drain plugs or valves	Drain radiators by removing pumps.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
			Drain radiators concurrent with draining the transformer.	
Radiator Cover Plates	Locate OEM radiator flange cover plates (radiator and transformer flanges), clean, and place them in a suitable storage location.	Cover plates are missing	Manufacture temporary plates and/or cover openings with plastic.	Substation Operations
Leak Inspection	Determine if there are existing leaks that must be corrected during the re-assembly process,	Leak observed, but gaskets are available	Replace gasket during the re-assembly phase.	Substation Operations
Replacement gaskets	Inventory and inspect all replacement gaskets for bushing, radiator, and pump flanges. Determine if gaskets exist for accessory devices like gages, etc., that need to be re-gasketed.	Leak observed, but gaskets are available	Obtain proper gasket material and hand make.	Substation Operations
Partial Oil removal	Determine if additional oil is to be removed to reduce the overall weight of the transformer. • 2,250 gallons over the core of the McGraw Transformer (TRF144) • Approximately 750 to 1,000 gallons over the core of the Westinghouse Transformer (TRF 140)	Decision made later to remove some of the oil.	Additional oil storage required.	Substation Operations Project Management
Obtain oil storage	Obtain suitable storage equipment for transformer oil.	Storage is not available or not large enough.	Obtain alternate temporary storage, i.e. • Tanker • Rubber pillow • Oil drums	Project Management
Plan for siting vacuum and oil	Ensure oil processing and vacuum equipment can be located close to the	Power not readily available,	Clean equipment	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
processing equipment **Functional test**	transformer and that there is suitable electric power available. Validate: • Oil hose availability and condition • Vacuum hose availability and condition • Adequate electrical power • Oil filter condition and availability • Misc. oil fittings condition and availability. • Perform functional test of all vacuum processing equipment	equipment contaminated, or equipment is not in working condition.	Repair or replace failed equipment Install temporary power feed.	
Dry Air and Nitrogen Supply	Obtain a sufficient number of Dry Air and Nitrogen cylinders Ensure availability of regulators	Cylinders not available	Purge transformer with atmosphere and extend the final dry out operation	Substation Operations
Safety Plan	Develop a plan to ensure the move is executed safely. This includes: • Identification of safe work areas • Safety watch • Hazard communication • Roles and responsibilities • Obtain required fall protection Obtain safety equipment for confined space work	Workers are unaware of hazards	Before the move, a detailed review of the plan, known hazards, and possible failures are thoroughly discussed and understood by all involved in the transformer move.	Project Management

Safety Awareness

This work will take place in and around the International Substation, which will be energized; all CEA and State of Alaska safety rules must be followed. Workers must be continually aware of the location of energized equipment and not violate safe working distances.

Success Metrics

This phase of the transformer move is successful when:

- All tasks are completed and documented
- All final inspections and diagnostics yield positive results and are documented
- Final functional testing of all oil handling equipment proves it is in working order and no hidden damage/failures.

Pre-move Civil/Mechanical Activity:

Introduction

Rolling a large power transformer to a new location is not a routine event and requires specialized tools and experience. The transformer is not to experience any sudden acceleration, de-acceleration, or impacts. The weight of the transformers must be uniformly supported at all times.

Goals

- Finalize the method for moving the transformer
- Validate the physical path is acceptable
- Identify and remove obstructions
- Detail mechanical requirements
- Elevate safety awareness
- Obtain an impact recorder for monitoring the move.

Risks

The major risks associated with performing these civil/mechanical planning tasks and achieving acceptable outcomes are:

- Lift Equipment is not available to meet project schedule
- Specialized skill sets are not available
- Soil conditions are not satisfactory
- Obstacles in the path.

Specialized Equipment

To complete these tasks, in addition to standard tools used by Substation Operating personal, the following tools are required:

- Impact Recorder
- Contractor provided:
    - Jacks
    - Winches
    - Rollers
    - Steel Plate/rails
    - Etc.

Main Tasks and Responsibilities

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Select method for moving the transformers	Select the best move option: • Lift with crane • Roll • Slide	Equipment not available.	Select alternate method	Project Management
Select Contractor	Select a contractor with sufficient skill, experience, staff, and equipment to move the transformers. *Note: Hannah General Contracting LLC (HGC) has been chosen to be the moving contractor.*	Inexperienced contractor selected.	Obtain alternate contractor	Project Management
Scope, Terms and Conditions	Develop a detailed contract that identifies: • Scope of work • Responsibilities • Risks o Electrical hazards o Sudden impacts to the transformer	Contract vague	Modify contract document to provide sufficient detail	Project Management Purchasing Department
Identify Move path	Select the most direct path that is: • Free of obstructions • Provides adequate electrical clearance • Is smooth and flat • Foundation height differential • Provides sufficient access for moving equipment	Limited space Path has obstacles. Path has abrupt elevation changes.	Clear/remove obstacles Grade/fill and compact the path	Substation Operations
Transformer Lift Height	Determine the height the transformer must be lifted to set on rollers and to avoid obstacles.	Height insufficient	Transformer to be jacked to an adequate height during move.	Moving Contractor
Determine Soil Conditions	Ensure the soil conditions along the move path are sufficient to support:	Hidden soil problems	Reduce or distribute the loads.	Engineering Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility

	• The transformer
	• Move equipment
	  o Trucks
	  o Lift equipment
	  o Winches, Jacks, etc.
	Review station construction and Geotech reports.
			Select an alternate path	

Roller Sizing and Placement	Determine the number, size, and location of the rollers used to move the transformer, ensuring OEM requirements are met. *Note: HGC will be using Hilman rollers along with "helper jacks" to support the load. Rollers will be position in appropriate locations under the base/walls of the transformer meeting the transformer OEM requirements.*	Rollers undersized or incorrectly placed	Detailed internal inspection of the transformer to determine the extent of physical damage	Equipment Moving Contractor
Transformer Rotation	Determine if the orientation of the transformer and whether it needs to be partially rotated prior to setting in its final location.	Not enough space to perform a rotation	Change path or provide additional space	Project Management Moving Contractor
Accessory Removal Review	Review the list of accessories to be removed and validate items left installed are not a hazard or obstacle. Removed items include: • Bushings • Arresters • Radiators • Pumps and Fans	Additional items need to be removed.	Add to the disassembly list.	Project Management Moving Contractor
Siting of moving equipment	Identify the location requirements of moving equipment along the full move path. Equipment includes: • Lift equipment • Winches/Jacks	Not enough space for moving equipment	Change path or provide additional space	Project Management Moving Contractor

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
	• Rollers • Steel plates and timbers • Etc.			
Staging	Identify staging area for moving equipment	Space is not adequate	Find new space	Substation Operations
Impact Recorder	Obtain an impact recorder to monitor acceleration in vertical, longitudinal, and lateral directions	Recorder not available	Monitor movement visually	Project Management
Review Electrical Clearances	Validate that safe working distances from energized equipment can be maintained along the move path and move activity. Fully understand how lift equipment is going to be used and positioned during the transformer move. *Note: MTEC reviewed requirements with HGC on 3/1/2021 and the 12" outer perimeter support requirements for the Westinghouse Shell Form Transformer.*	Energized equipment to close	Plan to de-energize before the move Revise move plan	Substation Operations
Detail Move Plan	Develop a step-by-step for moving the transformers including: • Jacking • Roller sizing and count • Roller Placement • Timber and plate placement • Winch/Jack placement • Cable sizing and placement • Rigging requirements • Auxiliary equipment requirements	Not enough detail	Add detail	Project Management Contract mover
Safety Plan	Develop a plan to ensure the move is executed safely. The plan includes: • Identification of safe work areas • Safety watch	Workers are unaware of hazards	Prior to the move, a detailed review of the plan, known hazards and	Project Management

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
	• Hazard communication • Roles and responsibilities		possible failures are thoroughly discussed and understood by all involved in the transformer move.	

Safety Awareness

This work will take place in and around an energized substation; all CEA and State of Alaska safety rules must be followed. Workers must be continually aware of the location of energized equipment and not violate safe working distances.

CEA workers are probably not intimately familiar with tools and equipment used by the moving contractor. The contractor must identify and communicate hazards and procedures.

Success Metrics

This phase of the transformer move is successful when:

- All tasks are completed and documented.
- Plan details each major step performed during the move and contingencies for unexpected events.
- All stakeholders are confident the move path and process are safe, executable and does not expose the transformer to excessive acceleration/de-acceleration forces.

Disassembly:

Introduction

Prior to moving the transformers, partial disassembly must occur to:

- Protect transformer subcomponents
- Reduce weight
- Reduce size
- Provide access to lifting and jacking points

Goals

- Disconnect all HV and LV connections as well as mechanical anchors.
- Isolate external control wires from the transformer.
- Temporarily remove some transformer subcomponents without damage
    - HV Bushings
    - HV Arresters
    - LV Arresters
    - Radiators. Etc.
- Minimize core and coil exposure to the outside air.
- Install cover plates to protect the transformer fittings from damage and contamination.
- Remove and store oil without contaminating or spilling.

Risks

The major risks associated with performing these disassembly tasks and achieving acceptable outcomes are:

- Bushing damage during the removal and storage processes
- Damage of the HV bushing draw lead
- Arrester damage during the removal and storage processes
- Contamination of the core and coils:
    - Water/moisture intrusion
    - Dirt and other contaminants
    - Dropping of nuts, bolts, washers, etc. during disassembly
- Flange and valve damage
- Radiator damage
- Radiator contamination:

  - Water/moisture intrusion
  - Dirt and other contaminants
- Oil spill
- Confined space hazards
- Fall hazards

Specialized Equipment

To complete these tasks, in addition to standard tools used by Substation Operating personal, the following tools are required:

- Fall Protection
- Confined Space Work Protection
- Boom Truck with Nylon Slings
- Oil Processing Equipment
- Oil Storage Equipment
- Bushing Crates/Stands
- Dry Air and Dry Nitrogen Cylinders with Pressure Regulators

Main Tasks and Responsibilities

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
De-energization and Safety Grounding	De-energize all the equipment in the worksite, test for dead, ground, and make it safe.	Hidden back feed	Ground all potential electrical sources and double-check.	Substation Operations
Safe Work Area	Clearly identify the work area and boundaries. Make sure the transformer moving contractor knows the locations of energized equipment and allowable safe working distances.	Not all boundaries are defined	Each day, before any work is performed, review in detail the safe work boundary with all project participants.	Substation Operations
Fall Protection	Install barriers, guards, restraints, etc. to protect workers against accident falling.	Inadequate fall protection	Install all necessary and required fall protection.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Control Wire Disconnect	Disconnect control wiring to the transformer. Remove conduit and other obstructions.	Control wiring left intact	Isolate and remove when discovered.	Substation Operations
HV and LV Bus Isolation	Remove all rigid and strain bus connections to bushings and arresters.	The remaining bus impedes move	Remove additional bus.	Substation Operations
Arrester Removal	Remove HV and LV Arresters	Arrester damaged during removal	Replace with new arrester	Substation Operations
Arrester Storage	Store arresters protecting them from damage and water ingress	Arrester improperly stored and water enters the vent	Replace with new arrester	Substation Operations
Weather Check	Ensure weather conditions are favorable for removing radiators and bushings not allowing excessive moisture into the transformer,	Poor weather conditions-rain	Delay until conditions are favorable. Install temporary "tent."	Project Management
Isolate and Drain Radiators (McGraw T-1)	Close radiator oil valves and isolate them from main tank. • Drain oil from the radiator before pump and radiator removal. • Follow oil with dry air or dry Nitrogen.	Isolation valves don't fully close	Remove oil from transformer prior to radiator and pump removal	Substation Operations
Pump Removal (McGraw T-1)	Remove oil pumps from McGraw Edison Transformer.	Isolation valves don't fully close	Remove oil from transformer prior to radiator and pump removal	Substation Operations
Pump Storage	Store pumps protecting them from damage, contamination, and water ingress	Not adequately protected.	Clean thoroughly. Send to pump repair shop	Substation Operations
Radiator Fan Disconnect (McGraw T-1)	On transformer T-1, disconnect the power leads to the fans so the radiators can be removed from transformer.	Connections broken	Repair before re-assembly	Substation Operations
Radiator Removal (McGraw T-1)	Remove radiators from the McGraw transformer (T-1): • Install cover plates on oil valves	Radiator damage caused by the removal process.	Patch/weld damaged fins.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
	• Install cover plates on radiator flanges • Cover flanges and valves with plastic sheeting.	Internal contamination of a radiator.	Special order replacement radiator from OEM or third party. Clean and flush radiator	
Radiator Storage	Store radiators in a location that protects them from incidental damage. Position them so the fins are not exposed to excessive forces.	Damage during storage.	Patch/weld damaged fins. Special order replacement radiator from OEM or third party.	Substation Operations
Log Core and Clamping Structure Exposure Time	Create a document that logs each exposure of the core, coils, and clamping structure to the atmosphere. This will be used to determine vacuum hold time. Include in the log: • Date • Core exposed or covered with oil • Start time of exposure • End time of the exposure • Total exposure time • Accumulated exposure time • Task being performed • Weather conditions *Note: It is very desirable not to lower the oil below the top of the coil insulation for long time periods. This will greatly reduce moisture absorption.*	Not logging exposure	Correct log. Estimate exposure time. Extend vacuum hold time prior to filling.	Project Management

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Purging with Dry Air	Purge blanket space with dry air using a minimum of two tanks of dry, breathing quality air. Measure Oxygen content; continue to purge until a 19% or higher oxygen level is reached.	19% Oxygen level not reached Excessive moist air is allowed into the transformer.	Extend purging process. Extend vacuum hold time during oil fill process	Substation Operations
Lowering of Oil Level	Lower the oil level to just below the top of the core but above the coils. Follow the oil with dry air.	Coils exposed	Return a portion of the removed oil to the transformer.	Substation Operations
HV Bushing Removal	Remove the HV bushings and ready for storage. • Position lift equipment for bushing removal. • Attach nylon slings to the bushing weather sheds • Remove busing terminal cap • Connect a long pulling wire/cord to the hole in the bushing stud. • Remove bushing stud holding screw/pin • Slowly lower draw-through lead into the transformer maintaining control of the pulling wire/cord. • Remove bolts that secure the bushing flange to the transformer. • Lift the bushing off the transformer while paying out draw-through wire/cord. • After the bushing is withdrawn from the transformer. Secure the draw-through lead to the top of the	Draw-through lead falls into transformer. Tool, bolt, nut, washer, etc. dropped into the transformer. Cover plates are not securely sealed.	Worker may need to climb into the transformer to inspect for damage and retrieve the draw-through lead. Dropped item must be recovered and removed from transformer. Inspect for damage. New gaskets installed with cover plate.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
	bushing cover plate and disconnect the pulling wire/cord. • Secure bushing cover plate ensuring proper gasket fit. • Repeat for remaining HV bushings. *Note: GE Type U HV bushing are to be replaced with new.*			
HV Bushing Storage	Store bushings in a secure location • Wipe oil off bushing • Wrap bushing in plastic • Set bushings: o At an angle, in a crate with top of bushing higher than the bottom (20° from horizontal minimum). or o Vertically in a crate or on bushing stands. • Store in a location where they won't get damaged.	Bushing not stored properly allowing bubbles into the condenser layers Physical damage to the bushing. Bushings contaminated.	Bushing must be replaced Close visual inspection to determine the extent of damage. Possible replacement required. Clean bushing thoroughly. Perform PF test.	Substation Operations
Remaining Oil Removal-If needed to reduce weight.	Remove all the oil from the transformer following with dry air. Filter and store oil in a clean tanker or portable oil storage container.	Contaminate storage container or tanker	Replace oil with new	Substation Operations
Tank Integrity Check	Visually inspect all flanges, valves and cover plates to ensure integrity. Pressurize transformer to 2.5 PSIG and check for leaks. Maintain positive pressure during the move.	Leak	Replace gaskets and re-seal. Continue until all leaks are corrected.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Final Isolation from Pad	Perform a final check to validate the transformer is both electrically and mechanically isolated from the substation.	Mechanical or electrical connection identified.	Remove connection	Substation Operations
				Substation Operations

Safety Awareness

This work will occur in and around the International Substation, which is energized; all CEA and State of Alaska safety rules must be followed. Workers must be continually aware of overhead lift equipment, the location of energized equipment and not violate safe working distances. Some work will take place on top of the transformer and may require incidental entry into the transformer. Workers must follow:

- Fall protection procedures
- Confined space procedures

Success Metrics

This phase of the transformer move is successful when:

- All tasks are completed and documented
- Coil and coil atmospheric exposure is less than 4 hours
- No contamination of the core and coils occurs
- Radiators are removed and safely stored without damage
- HV bushings are removed and safely stored without damage
- HV and LV arresters are removed and safely stored without damage
- No oil spills
- No oil contamination
- Tank is tightly sealed, and integrity validated.

MAINTENANCE & TEST ENGINEERING, LLC

Relocation:

Introduction

Movement of the partially disassembled transformer from the existing foundation to the new foundation will be performed by Hannah General Contractors LLC-an experienced, heavy equipment contractor. The process includes:

- Jacking the transformer to the required clearance height
- Placing steel plates or beams along the relocation path
- Installing Hilman rollers at lift points identified by the OEM
- Rolling the transformer to the new foundation
- Removing rollers and setting the transformer on the new foundation pad

Goals

- Jack, roll and set the transformer without exceeding transformer OEM acceleration/deacceleration forces.
- Ensure roller point loads do not exceed transformer structural ratings.
- Fully control the movement of the transformer from initial lift to final setting.

Risks

The major risks associated with performing the relocation task and achieving acceptable outcomes are:

- Sudden impacts.
- Loss of movement control.
- Roller or jacking point loads exceeding transformer rating.
- Insufficient soil compressive strength.

Main Tasks and Responsibilities

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Install Impact Recorder	Install electronic accelerometer to record transformer acceleration in three planes: • Vertical • Longitudinal • Transverse	Impact recorder non-functional	Repair the recorder Video tape all transformer movement	Project Management

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Log Events	Keep a log of salient activity recording: • Date • Time • Event description • Responsible party • Observations	Failure to record important event.	Relay on consensus observations	Project Management
Validate Lift Height	Validate that the initially estimated height that the transformer must be lifted is adequate to clear obstacles and to be set on the new foundation is correct,	Lift height underestimated	Perform a second lift during the move event.	Equipment Moving Contractor
Validate Roller Sizing and Placement	Validate the initial number, size, and location of the rollers to be used to move the transformer are correct, ensuring OEM requirements are met. *Note: For the Westinghouse Transformer (TRF140), rollers must be confined to the 12' outer perimeter-supporting the transformer's walls.*	Rollers undersized or incorrectly placed	Detailed internal inspection of the transformer to determine the extent of physical damage	Equipment Moving Contractor
Activate Impact Recorder	Start recording all transformer movements using an electronic accelerometer.	Fail to record movement	Relay on consensus observations	Project Management
Plate/Rail Placement	Place steel plates or rails along the transformer move path.	Plates/rails improperly installed stopping transformer movement	Jack and reposition plates/rails	Equipment Moving Contractor
Transformer Lift	Lift the transformer to the required height, install Hilman rollers, plates, etc., to achieve proper transformer weight distribution.	Rollers or jacks undersized or incorrectly placed	Detailed internal inspection of the transformer to determine the extent of physical damage	Project Management
Transformer Move	Using winches/jacks, move the transformer along the path. The movement will be 100% controlled during the whole time to stop movement immediately upon command.	Loss of movement control resulting in sudden acceleration/de-acceleration.	Review of impact recording. Detailed testing and internal inspection	Equipment Moving Contractor

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
			of the transformer to determine the extent of physical damage	
Transformer Set	Set the transformer on the new foundation at the prescribed location and orientation.	Set in the wrong location	Move the transformer to the correct location Adjust bus/electrical connections	Equipment Moving Contractor
Deactivate Impact Recorder	Stop recording all transformer movements using the electronic accelerometer.	The impact recorder stopped working during the move.	Relay on consensus observations	Project Management
Impact Recorder Data Assessment	Review transformer acceleration/de-acceleration recording making sure limits were not exceeded: • Vertical (3.0G) • Longitudinal (2.5G) • Transverse (1.5G)	Acceleration/Deacceleration limits exceeded.	Detailed testing and internal inspection of the transformer to determine the extent of physical damage	Project Management
Roller and Plate/Rail Removal	Remove all moving equipment from the International Substation.	Plate or roller stuck under transformer	Jack transformer to remove the plate or roller. Add additional plates to level transformer and distribute loads	Equipment Moving Contractor

Safety Awareness

This work will take place in and around an energized substation, all CEA and State of Alaska safety rules must be followed. Workers must be continually aware of the location of energized equipment and not violate safe working distances. The movement of the transformers will require significant forces, workers must be aware of:

- Hazards associated with steel pulling cables hydraulic jacks failing

- Inertia and hazards associated with a large moving mass

Success Metrics

This phase of the transformer move is successful when:

- All tasks are completed and documented
- Movements are slow and controlled with accelerations/deacceleration limits not exceeded.
- No excessive tilting (more than 15° from vertical) of the transformer.
- No unplanned contacts or collisions with surrounding equipment.

Re-assembly:

Introduction

After moving the transformers, re-assembly must occur. The re-assembly tasks include:

- Return and install removed subcomponents to their functioning position.
- Removal of air and moisture from the core and coil assembly that were introduced during the disassembly process.
- Drying the windings as needed.
- Vacuum filling the transformer with filtered and dehumidified insulating oil.
- Connecting CTs and control equipment

Goals

- Remove cover plates used to protect the transformer fittings from damage and contamination
- Re-install transformer subcomponents without damage
- Minimize core and coil exposure to outside air
- Reconnect all HV, LV and control wire connections as well as mechanical anchors
- Oil fill without contaminating or spilling

Risks

The major risks associated with performing these disassembly tasks and achieving acceptable outcomes are:

- HV bushing damage during the installation processes
- Damage of the HV bushing draw lead
- Contamination of the core and coils:
    - Water/moisture intrusion
    - Dirt and other contaminants
    - Dropping of nuts, bolts, washers, etc. during disassembly
- Flange and valve damage
- Radiator damage
- Radiator contamination:
    - Water/moisture intrusion
    - Dirt and other contaminants
- Oil spill
- Confined space hazards
- Fall hazards

Specialized Equipment

To complete these tasks, in addition to standard tools used by Substation Operating personal, the following tools are required:

- Dew Point Tester
- Fall Protection
- Confined Space Work Protection
- Boom Truck with Nylon Slings
- Oil Processing Equipment
- Oil Storage Equipment
- Dry Air and Dry Nitrogen Cylinders with Pressure Regulators

Main Tasks and Responsibilities

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Final Location on Pad	Perform a final check to validate the transformer is located on the transformer pad correctly.	Incorrect location.	Reposition the transformer	Substation Operations
LV Grounding	Short circuit and ground the LV bushings (assuming they were not removed)	Grounds not applied	Grounds must be applied before vacuum oil filling process.	Substation Operations
Fall Protection	Install barriers, guards, restraints, etc., to protect workers against accident falling.	Inadequate fall protection	Install all necessary and required fall protection.	Substation Operations
Tank Integrity Check	Visually inspect all flanges, valves, and cover plates to ensure integrity. Validate a positive pressure was kept on the transformer core and coils during the move.	Flange Damage Leak	Repair flange Replace gaskets and re-seal. Increase vacuum hold time	Substation Operations
Dew Point Test	If the transformer has held positive pressure and appears to have no excessive leaks, perform a dew-point test to confirm dryness	Transformer leaks	Dew-point test will be inaccurate and will overstate state	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
			dryness-rely on other tests.	
Log Core, Coil and Clamping Structure Exposure Time	Create a document that logs each exposure of the core, coils, and clamping structure to the atmosphere. This will be used to determine vacuum hold time. Include in the log: • Date • Core exposed or covered with oil • Start time of exposure • End time of the exposure • Total exposure time • Accumulated exposure time • Task being performed • Weather conditions *Note: It is very desirable not to lower the oil below the top of the coil insulation for long time periods. This will greatly reduce moisture absorption.*	Not logging all exposure	Correct log, estimate exposure times. Extend vacuum hold time prior to filling.	Project Management
Install Radiators (T-1 McGraw Edison)	Install radiators on the McGraw transformer: • Inspect radiators for damage • Remove plastic flange covers • Remove cover plates on oil valves and wipe/clean all surfaces. • Remove cover plates on radiator flanges and wipe/clean all surfaces. • Install new flange gaskets	Radiator damage caused by the installation process. Internal contamination of a radiator.	Patch/weld damaged fins. Special order replacement radiator from OEM or third party. Clean and flush radiator	Substation Operations
Pump Installation (McGraw T-1)	Install Oil Pumps on McGraw Edison Transformer. • Remove plastic flange covers • Wipe/clean all flange surfaces.	Damage flanges	Replace or re-machine damaged parts	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
	• Install new gaskets • Connect to power			
Reconnect Fan	Reconnect fan power leads	Connections broken	Repair before energization.	Substation Operations
Pressure Test	With oil tank valves closed, pressurize radiators and pumps to 2.5 PSIG with Nitrogen. Check for leaks.	Leak discovered	Tighten, re-gasket or re-seal.	Substation Operations
HV Bushing Installation	Remove the HV bushings from storage and re-install or install new replacement bushings. • Position lift equipment for bushing Installation. • Thoroughly clean the bushing with alcohol or other acceptable non-water based cleaner. • Remove bushing cover plate and secure the pulling lead for the draw-through lead. • Install and position new bushing flange gasket. • Attach nylon slings to the bushing weather sheds • Remove busing terminal cap • Position bushing over top of transformer. • Thread draw-through lead pulling wire through bushing. • Slowly lower bushing into the transformer while pulling up the draw-through lead maintaining control of the pulling wire/cord. • Install bushing stud holding screw/pin	Draw-through lead falls into transformer Tool, bolt, but, washer, ort etc. dropped into the transformer. Bushings are dirty Cover plates are not securely sealed.	Worker may need to climb into the transformer to inspect for damage and retrieve the draw-through lead. Dropped item must be recovered and removed from transformer. Inspect for damage. New gaskets installed with cover plate. Oil contaminated and may need to be replaced.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
	• Install bushing cap, tighten per Manufacturer's recommendations • Install bolts that secure the bushing flange to the transformer. Repeat for remaining HV bushings			
HV Grounding	Short circuit and ground the HV bushings	Grounds not applied	Grounds must be applied before vacuum oil filling process.	Substation Operations
Gasket Replacement	Replace gaskets as required on: • Inspection covers • Temperature and oil level gages • Etc.	Replacement gasket not available	Custom cut replacement gasket	Substation Operations
Pressure Test	Open all radiator and pump valves. Pressurize transformer to 2.5 PSIG using dry air or Nitrogen.	Misc. leak LV bushing gasket leak (bushing not removed during disassembly process)	Tighten connection or replace aged gasket Replace gasket on LV bushings by: • Validating safe level of Oxygen in transformer. • Prepare for entry by flowing dry air into the transformer and following all confined space rules	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
			• Enter the transformer wearing clean-disposable coveralls, shoe covers etc. • Disconnect LV bushing from transformer, do not drop tolls, bolts, washers or nuts. • Remove bushing flange nuts • Pull bushing out. • Clean and re-gasket • Re-install bushing. • Tighten flange bolts • Reconnect to transformer.	
Connect Oil Processing Equipment	Ready the transformer for vacuum drying and oil filling. • Clean all connections • Tighten for full vacuum	Dirty connections Connections leak	Clean connections Tighten/re-gasket as necessary.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
	• Close all nitrogen/inert air valves			
Determine Vacuum Hold Time	Review log and determine the amount of time the core and coils were exposed to the atmosphere. Vacuum hold time to be four (4) hours plus one (1) hour for each eight (8) hours of core and coil exposure.	Exposure time was not accurately recorded	Estimate exposure time and error on the high side.	Project management
Vacuum Integrity Check	Evacuate transformer and oil hoses to 1000 microns or less: • Isolate vacuum pump and hoses • Record drop on vacuum in transformer over the next 30 minutes to determine if there are leaks.	Leaks detected.	Re-pressurize transformer with dry air or Nitrogen Fix leaks Perform another vacuum integrity check,	Substation Operations
Vacuum Dry	Apply full vacuum (500 microns or less) and hold for the length of time calculated above. *four (4) hours plus one (1) hour for each eight (8) hours of core and coil exposure*.	Leaks detected.	Re-pressurize transformer with dry air or Nitrogen Fix leaks Perform another vacuum integrity check,	Substation Operations
Vacuum Fill	Top fill the transformer with filtered, vacuum dried oil. Maintain a vacuum of 2,000 microns or less.	Vacuum exceeds 2,000 microns	Slow the oil fill rate	Substation Operations
Pressurize	After oil filling, pressurize the Inertaire space with 2.5 PSIG Nitrogen	Contamination with water or air	Remove and reprocess oil.	Substation Operations
Arrester Installation	Re-install HV and LV Arresters	Arrester damaged during storage or installation	Replace with new arrester	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
Reconnect Control Wire	Reconnect control wiring to the transformer including. • Power • CTs • Protection and Controls Validate CT Polarity	Station wiring not complete	Testing of pumps and fans will be delayed.	Substation Operations
Test Pumps	Validate pumps rotate in proper direction forcing oil down the radiators into the transformer.	Reverse rotation	Change power leads to obtain correct rotation.	Substation Operations
Remove Oil Processing Equipment	Disconnect all vacuum and oil processing equipment from the transformer. After successful completion of the quality and acceptance tests listed below, clean and store appropriately.	Not properly stored	Excessive star-up work during the next transformer fill.	Substation Operations

Safety Awareness

This work will take place in and around the International Substation, which is energized; all CEA and State of Alaska safety rules must be followed. Workers must be continually aware of the location of energized equipment and not violate safe working distances. Additionally, workers must:

- Utilize appropriate fall protection
- Follow confined space work rules
- Not be allowed to be on top of the transformer during any vacuum operation.

Success Metrics

This phase of the transformer move is successful when:

- All tasks are completed and documented
- There are no recorded oil spills
- Transformer is fully assembled

Quality and Acceptance Test:

Introduction

After the transformer is fully assembled and oil filled, a series of tests are to be performed to validate the work was performed in a quality manner, there are no hidden problems and the transformer is fit to return to service.

Goals

The goals of the Quality and Acceptance Test Tasks are to:

- Determine if excessive movement of the core and coils occurred during transformer relocation,
- Validate the transformer was sufficiently dried and oil is in good condition.

Risks

The major risks associated with performing these Quality and Acceptance tasks and achieving acceptable outcomes are:

- Fall hazards
- Inconclusive test results

Specialized Equipment

To complete these tasks, in addition to standard tools used by Substation Operating personal, the following tools are required:

- TTR
- Power Factor Test Set
- SFRA Test Set

Main Tasks and Responsibilities

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
TTR	Perform Transformer Turns Ratio Test	Wrong ratio	Determine if NLTC must be moved to a different tap.	Substation Operations

Task Name	Objective	Failure/Negative Outcome	Failure Action	Responsibility
			Determine the cause for the ratio error..	
PF Test-Winding	Identify potential moisture problems	High PF	Correlate with other tests	Substation Operations
Excitation Test	Determine if there are shorted turns or winding movement.	High exciting current	Correlate with other tests	Substation Operations
SFRA Test	Determine if the coil assembly has experience excessive impact forces during move.	Excessive movement detected	Visually inspect. Possibly plan for early replacement	Substation Operations
Oil Quality Test	Determine moisture content	High water content • Actual • Sample error Lab error	Extra vacuum processing time required to dry core and coils Re-sample and re-test	Substation Operations
Control and Protection	Validate all control and protection functions operate properly.	Mis-wiring	Correct wiring and validate	Substation Operations

Safety Awareness

This work will take place in and around the International Substation, which is energized; all CEA and State of Alaska safety rules must be followed. Workers must be continually aware of the location of energized equipment and not violate safe working distances. Additionally, the worker must recognize and follow:

- Fall protection rules
- During testing that safety grounds will be temporarily removed.

Success Metrics

This phase of the transformer move is successful when:

- All tasks are completed and documented

- No movement of core and coils is detected
- No excessive winding moisture detected
- Oil is dry with no dissolved gas other than Nitrogen.