Basic Mobile Sub Design

- Equipment mounted on semi-trailer
- Power transformer
- High and Low side disconnects
- High and Low side protection devices
- Cooling equipment for Transformer
- Regulators or LTC
NSP MS-06
Basic Mobile Sub Design
External Equipment

- Source connection, aka Flying Tap
- 3 single phase voltage regulators
- Drag cables to connect load side
- Temporary switch between drags and load
External Equipment
Source & Load Connections
Installing a Mobile Substation

- Looks easy on paper
Electrical Design of Mobile Installation

- Select mobile with correct primary & secondary voltages
- Select mobile with correct MVA rating for load served
- Choose tap settings so turns ratios are close to same value
- Correct phase shift
- Protection settings for new configuration
Example: Tap Settings

- Station Transformer DETC Tap position 1 = 70725V : 12990V. Ratio of 5.44
- Using low side of Mobile Sub Transformer chosen, 13.09 kV x 5.44 = 71.269kV
- Closest options for Mobile Sub Transformer DETC Tap are 72.4kV or 70.6kV, yielding ratio of 5.5 or 5.39
- Tap setting that yields ratio of 5.39 chosen since it is closer to 5.44
Transformer Phase Angles

- Phase angle shift of mobile should match that of substation transformer it replaces.
- If not, swapping 2 phases on source connection can fix this or do a drop and pick.
Physical Installation Design

- Location to park mobile substation
  - Typically under source line
  - Close to distribution bus or line
  - Far away from scheduled activity
- Room enough for clearances
- Level location
- Temporary Fencing
- Tie to substation ground grid
Physical Installation Design

- Generally the further away mobile is from work area, the better
- Sometimes this requires parking mobile on private or public property (vacant lot, corn field, ditch, street)
Physical Installation Design

- Prepare one line sketch showing where mobile will be connected to transmission line and distribution line
- Prepare location plan showing where mobile will be parked, temporary transmission and distribution poles & lines and physical access
- Meet on site with personnel for transmission, substation, distribution, Siting & Land Rights, etc.
Physical Installation Design

- Location plan drawing
Physical Installation Design

- One line drawing
Serving Load During Substation Rebuilds

- If project is to upgrade or replace an existing substation
  - Will mobile be needed for an extended period of time?
  - Will mobile be clear of substation construction activity?
Has issue to build temporary distribution and transmission facilities for connection of mobile been considered?

Can a mobile be tied up for entire construction period?

Are there alternatives that don’t require use of a mobile?
Testing

- Overall power factor
- Transformer turns ratio
- Winding resistance
- Excitation
- Oil sampled for baseline DGA
- Relay settings
Installation Checklist

- Guide for installing and energizing mobile substation
- Unique to each mobile substation
- Used by Foreman and Engineer on-site to verify correct installation
- Detailed steps to energize a ‘lights out’ system or parallel with substation transformer
Safety Considerations

- Electrical clearances
- Onboard equipment failures awareness
  (equipment is low to ground, new installation)
- Oil containment considerations
- Personnel escape plan
- Adequate grounding
Lessons Learned – Load Check

- Circuit breaker with shunt trip coils
- Current ratios must be correct
- Load current could cause trip
Lessons Learned – Phase Check

- Map out how phases connect
- Order of H1, H2, H3 is more important than A, B, C
- Mobile transformer are Delta-Wye, 30-degree lagging
- Occasionally substations are 30 leading
- Proper phase check will catch if mobile is incorrectly installed
Lessons Learned – Functionality Test

- Tests circuit breaker
- Problems can be discovered
- Vacuum recloser stopped working
- Called manufacturer to solve problem
Lessons Learned – Sensitive Relays

- Electro-mechanical relays can be sensitive to vibrations
- Tripped a mobile while shutting cabinet door
- CO relay for thermal overload
- Could not replicate problem
- Shut door gently, kept fingers crossed
Lessons Learned – Review Checklist When Conditions Change

- Mobile transformer taken out of service via high side fuses - was energized single phase
- Blew secondary fuses on oil pumps
- Status of pumps not checked when TR was re-energized
- Transformer failed within hours
- Verify all systems working with checklist
Lessons Learned – Field Testing

- De-energized tap switch broke when operated
- No testing, so this was not known
- Mobile energized and fuses operated
- Changes resulting from this near miss
  - Test mobile before any installation
  - 30-second time delay on high side MOD
  - 2 exit gates on temporary fence
Lessons Learned – Location

- Mobile Sub used to support construction project, also near active rail line
- Vibrations of truck and train traffic loosened blade of high side switch
- Blades were not seated properly in the jaws
- Repairs were made in the field
- Visit mobiles that are installed for long periods to check for issues and IR it
Lessons Learned – Replace a Grounding Bank

- 69-23.9kV delta-delta TR with a grounding bank for relay protection and ground source
- Ground bank failed
- Mobile sub installed to take its place
  - Low side connected to system
  - High side left disconnected
THANK YOU