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Meeting Notes

Subject:	Arc Flash Mitigation Planning Workshop		
Client:	HRSD		
Project:	Arc Flash Mitigation Workshops	Project No:	214032
Meeting Date:	July 9-10, 2013	Meeting Location:	HRSD South Shore Operations Center, Atlantic Conference Room
Notes by:	B. M'Coy		

Attendees:

HRSD

Sherman Pressey	Tim Marsh	Stan Saunders
Carolyn Cagle	Stephanie Laughinghouse	Lee Inman
John Haymore	Ryan Duke	Kelly Lamp
Jennifer See	Mardane McLemore	Rick Raike

HDR

Gary Useldinger	Natalie Wieszek
Bill M'Coy	Kevin Thernes

Notes:

Primary HRSD Arc Flash Hazards:

1. Mechanical lock out/tag out by non-qualified personnel – treatment plants and pump stations (unattended).
2. Work on Greater Than Category 4 equipment by qualified electrical personnel.
3. Energized work in emergencies.
4. Hand-Off-Auto (HOA) selector switches located on motor control centers (MCCs) and variable frequency drive (VFD) panels – treatment plants and pump stations.

HRSD Arc Flash Program Goals:

1. Reduce arc flash hazard/risk category to Category 2 or lower (MCC and VFD panels should be reduced to Category 0).
2. Resolve issues with lock out/tag out by non-qualified personnel.
3. Determine method to manage changes to equipment and standard procedures:
   a. Standards & Preferences.
   b. Software (SKM model updates) and hardcopy documentation.
      i. Who will manage; where stored.
      ii. How will changes be tracked.
   c. Manage through construction.
4. Electrical Safety Program in compliance with standards.
   a. Training and qualifying personnel.

HRSD Mitigation Actions to Date:

1. Prepared Draft Electrical Safety Program (held up on lock out/tag out issue).
2. Initiated pilot program at Virginia Initiative Plant (VIP) - mechanical lock out/tag out:
   a. Local shared PPE at equipment (Category 2) - Grit MCC.
   b. Remote Switching Operator (RSO) device - RAS MCC.
3. Purchased Eaton remote racking device for switchgear breakers (located at VIP Blower Building).
4. Developed form for tracking equipment changes.

5. Conducted re-training for all qualified electrical personnel on NFPA 70E.
6. Installed permanent remote operating panel for opening/closing existing 2SB1 main circuit breakers at VIP.
7. Retrofitted circuit breakers with AC-PRO with QUICK-TRIP trip units to provide adjustable long time, short time, and instantaneous settings (LSI) at VIP.
8. Installing Arc Reduction Maintenance Switch (ARMS) and maintenance bypass transfer switches at Army Base Treatment Plant (ABTP).
9. VIP NRI design will include separate enclosures for the Main Switchgear main circuit breakers at VIP.
10. Compiled spreadsheet of electrical equipment with respective arc flash hazard/risk categories.

Potential Arc Flash Mitigation Alternatives for Medium Voltage Switchgear:

New	Retrofit Existing
Bus differential relays installed in switchgear • Approximately $5k • There is a concern with nuisance tripping	Bus differential relays installed in switchgear • Approximately $5k • There is a concern with nuisance tripping
Maintenance bypass switch on main and feeder circuit breakers	Maintenance bypass switch on main and feeder circuit breakers
Separate main circuit breaker • Partitions in switchgear • Separate rooms • Separate space in room	Clean air/filtration/climate control (applies to all equipment)
Permanent remote operator	Permanent remote operator
Arc flash sensing relay	Arc flash sensing relay
Main-tie-tie-main configuration (doubled ended switchgear)	Upgrade induction disc relays to microprocessor relays
5-cycle breakers	

Potential Arc Flash Mitigation Alternatives for Medium Voltage MCC:

New	Retrofit Existing
Remove HOA from MCC	Remove HOA from MCC
Bus differential installed in switchgear • Approximately $5k • There is a concern with nuisance tripping	Bus differential installed in switchgear • Approximately $5k • There is a concern with nuisance tripping
Maintenance bypass switch	Maintenance bypass switch
Separate main circuit breaker • Partitions in switchgear • Separate rooms • Separate space in room	Clean air/filtration/climate control (applies to all equipment)
Permanent remote operator	Permanent remote operator
Arc flash sensing relay	Arc flash sensing relay
Main-tie-tie-main configuration (double ended switchgear)	Upgrade induction disc relays to microprocessor relays
5-cycle breakers	

Potential Arc Flash Mitigation Alternatives for Low Voltage Switchgear:

New	Retrofit Existing
Maintenance bypass at upstream medium voltage feeder and/or at main circuit breaker	Retrofit unit substations (3.F. in Attachment A)
Remote open/close and remote racking	Remote open/close and remote racking
Separate main circuit breaker from switchgear	Remove main circuit breaker and install in separate location (if possible)
Arc flash sensing relay	Arc flash sensing relay
Arc Vault	Arc Vault
Zone selective interlocking (ZSI)	ZSI

Potential Arc Flash Mitigation Alternatives for Low Voltage Switchboards:

New	Retrofit Existing
Not preferred for new equipment	Replace with switchgear
Separate main circuit breaker from switchboard	Remove main circuit breaker and install in separate location
Arc Vault	Arc vault
Maintenance bypass switch at upstream feeder circuit breaker and/or at main circuit breaker	Maintenance bypass switch at upstream feeder circuit breaker and/or at main circuit breaker
	Remote open/close of insulated case circuit breakers

Potential Arc Flash Mitigation Alternatives for Low Voltage MCC:

New	Retrofit Existing
Separate main circuit breaker from MCC	Remove main circuit breaker and install in separate location (if possible)
Solid state trip unit on upstream feeder circuit breaker and/or main circuit breaker	Solid state trip unit on upstream feeder circuit breaker and/or main circuit breaker
Remote racking	Remote switch operator (RSO)
Arc Vault	Arc Vault

Potential Arc Flash Mitigation Alternatives for Low Voltage VFD and Control Panels:

New	Retrofit Existing
Remote mount HOAs (Category 1 or higher)	Remote mount HOAs (Category 1 or higher)
Solid state trip unit (LSI) on upstream feeder circuit breakers to VFDs and main circuit breakers	

Potential Arc Flash Mitigation Alternatives for Low Voltage Power Panels and Transfer Switches:

New	Retrofit Existing
Addressed by upstream protective device	
Address construction quality in Standards & Preferences	

Alternatives to be Evaluated for Lowering Arc Flash Hazard Category in Pump Stations:

New	Retrofit Existing
Main circuit breaker mounted outside	Main circuit breaker mounted outside
Install upstream separately-mounted circuit breaker	Install upstream separately-mounted circuit breaker
Smart MCC with networking	Remote switching

Alternatives to be Evaluated to Address Pump Station Equipment Lock Out/Tag Out:

New	Retrofit Existing
Local disconnect with remote start/stop	Local disconnect with remote start/stop
Remote switching	Remote switching
Personal protective equipment (PPE)	PPE
Achieve Category 0 at pump station	Achieve Category 0 at pump station

Alternatives to be Evaluated to Address Plant HOAs:

New	Retrofit Existing
HOA located at process equipment without VFD	Achieve Category 0 at MCC/VFD panel
HOA on VFD with DCS shutdown	Relocate HOA to motor/equipment
Local disconnect at all equipment with DCS shutdown	Connect to DCS
HOA located at HVAC equipment	

Alternatives to be Evaluated to Address Plant Equipment Lock out/Tag out:

New and Retrofit	Retrofit Existing
Local disconnect switch at all equipment with DCS shutdown	RSO devices (all categories)
Design for Category 0 at applicable panels (MCCs, VFD panels, control panels, etc.)	PPE (Category 2 or lower)
	Modify circuit breakers
	Change protective schemes

Criteria that will be used to evaluate alternatives:

- Initial cost
- Safety – achieve low arc flash hazard/risk
- Risk – loss of operation
- Ease of operation
- Reliability – of implemented equipment
- Versatility - addresses lock out/tag out and electrical work
- Annual cost
- Feasibility/Maintaining operation

Preliminary Decisions:

1. Existing pump stations and new pump stations (< 400A service):
   a. Use portable remote switching operator (RSO) devices.
   b. Relocate HOAs off of MCC.
   c. For new pump stations, separately-mount main circuit breaker inside the pump station.
2. New pump stations (≥ 400A service):
   a. Install main circuit breaker with adjustable LSI trip unit and remote switching.
   b. Separately-mount main circuit breaker inside the pump station.
   c. For Greater Than Category 4 areas, workers need to have utility shut down power at their end to work on main circuit breaker.
   d. HOAs mounted off of MCC.
   e. Consider using SCADA to shutdown equipment and install local disconnect switches.

Miscellaneous Notes:

1. 5 year audit - does it require upgrade to current code?
2. Arc flash labels - equipment based or task based?
3. Who tracks/maintains software?
4. Testing should include circuit breaker trip time.
5. Work on electrical equipment with a Greater Than Category 4 rating at plants by qualified electrical personnel requires equipment to be de-energized prior to work.

Action Items:

1. HDR to draft Standard & Preferences language for new pump station electrical service configuration.
2. HRSD to procure RSO devices for existing pump stations.
3. HRSD to contract relocation of HOAs in existing pump stations.
4. HDR to evaluate actions to achieve Category 0 at MCCs, VFD panels, and other applicable panels requiring lock out/tag out at VIP, one larger pump station, and one smaller pump station. Also, evaluate relocation of HOAs to motors at VIP. Consider risk reduction (Category 2 or lower) for electrical work at distribution equipment.
5. HRSD complete pilot testing of RSO devices and PPE at VIP.
6. HDR draft Standard & Preferences language for MCCs, VFD panels, and other applicable panels in new plant designs to address lock out/tag out (goal to achieve Category 0l, with adding local disconnects as alternative). Also, installing motorized circuit breakers that feed large VFD panels).
7. HRSD to develop cost for installation of local disconnect switches at two pump stations.
8. HDR draft Standard & Preferences language to address HOAs on new plant designs.
9. HDR draft Standard & Preferences language on managing construction process relative to arc flash (equipment shop drawings, etc.).
10. HRSD and HDR will schedule a follow-up one-day workshop upon completion of the evaluations listed in Actions Items 4 and 7.

Attachment A
Typical Approaches to Limiting Arc Flash Exposure

Limiting Arc Exposure

1. Avoiding arc flash accidents
2. Reducing the level of arc energy released
3. Proper use of personal protective equipment (PPE)

Avoiding Arc Flash Accidents

1. Preventive maintenance
    a. Keep equipment clean.
    b. Keep rodents and birds out of equipment.
    c. Control and repair corrosion of enclosure and electric components.
    d. Check for loose connections.
    e. Test insulation integrity.
    f. Test and repair relays/trip units and breakers.
    g. Test and repair moving parts (breaker racking, switch operation, etc.)
2. Working on Live Equipment
    a. If possible, always work on de-energized equipment.
    b. Use insulated tools.
    c. When excessive force is needed (loosening bolts), it is not uncommon to lose control.
    d. Do not use paint, cleaning chemicals, spray lubrication, etc. on live parts.

Reducing Incident Energy on Worker

1. Reduce the level of Fault
    a. Use smaller kVA transformers.
    b. Double ended switchgear:
        i. Keep tie breaker open in Main-Tie-Main configurations.
        ii. Use only one source of a Main-Main configuration.
        iii. Utilize two line-ups in a Main-Tie-Tie-Main configuration instead of one line-up in a Main-Tie-Main.
    c. Current limiting fuses or breakers.
    d. Current limiting reactors.
2. Reduce arcing time
    a. Reduce breaker response time safety margin.
        i. Replace electro-mechanical relays with microprocessor relays allows time margin between relays to be reduced from 0.4 second to 0.2 – 0.25 seconds.
        ii. Utilized 5 cycle breakers rather than 8 cycle breakers.
    b. Bus differential protection.
    c. Zone selective interlocking (ZSI).
    d. Temporary instantaneous settings:
        i. Arc maintenance settings on trip units.
        ii. Maintenance group setting on microprocessor relays.
        iii. Add instantaneous trip devices to breakers with no instantaneous that can be turned on and off.
    e. Arc flash sensing relays via fiber optical cable.
    f. Adjust fuse size and speed.
    g. General Electric Arc Vault.
    h. High/Low resistance grounding.
3. Equipment features
    a. Remote breaker operation (open/close).
    b. Remote breaker racking.
    c. Arc flash resistant MCC and switchgear. (not effective with doors open)
    d. MCC that can rack bucket out with door closed.
    e. Locate main breaker section remote (separate room) from distribution section.
    f. Retrofit unit substations (primary fuse switch with secondary feeder breakers) with secondary CT and relay and primary switch over breaker with trip unit to provide both primary and secondary protection.
    g. Remote switching operator (RSO) device.

SKM SYSTEMS ANALYSIS, INC

SHORT-CIRCUIT/COORDINATION STUDY/ARC

FLASH RISK ASSESSMENT

PART 1 GENERAL

1.1 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies as prepared by the electrical equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Risk Assessment Study per the requirements set forth in NFPA 70E - Standard for Electrical Safety in the Workplace. The arc flash risk assessment shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D.

C. The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract. - OR - The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract as well as all directly affected existing distribution equipment at the customer facility. - OR - The scope of the studies shall include all new distribution equipment supplied by the equipment

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):

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

2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.

C. The National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.3 SUBMITTALS FOR REVIEW/APPROVAL

A. The short-circuit and protective device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1.4 SUBMITTALS FOR CONSTRUCTION

A. The results of the short-circuit, protective device coordination and arc flash risk assessment studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies of the short-circuit input and output data, where required, shall be provided on CD in PDF format.

B. Following best practices, the contractor is to provide the study project files to the Owner in electronic format to allow the Owner to review all aspects of the project input data and reprint arc flash labels, one-line diagrams, reports etc. The electronic project files are critical for disaster recovery and maintaining the power system. In addition, a copy the PTW Viewer program is required to accompany the electronic project files (or Owner to purchase directly from SKM).

C. The report shall include the following sections:

1. Executive Summary.
2. Descriptions, purpose, basis and scope of the study
3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties
4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
5. Fault current calculations including a definition of terms and guide for

interpretation of the computer printout.

6. Details of the incident energy and flash protection boundary calculations
7. Recommendations for system improvements, where needed.
8. One-line diagram

D. Arc flash labels shall be provided in hard copy only. -OR- Arc flash labels shall be provided in hard copy and for large system studies with more than 200 bus locations, a copy of the electronic format.

1.5 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash risk assessment studies shall be conducted under the supervision and approval of a Registered/Licensed Professional Electrical Engineer skilled in performing and interpreting the power system studies.

B. The Registered/Licensed Professional Electrical Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm

C. The Registered/Licensed Professional Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies.

D. The equipment manufacturer or approved engineering firm shall demonstrate experience with Arc Flash Risk Assessment by submitting names of at least ten actual arc flash risk assessment it has performed in the past year.

1.6 COMPUTER ANALYSIS SOFTWARE

A. The studies shall be performed using the latest revision of the SKM Systems Analysis Power*Tools for Windows (PTW) software program or approved equal.

PART 2 PRODUCT

2.1 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Risk Assessment Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Annex D.

2.2 DATA COLLECTION

A. Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash risk assessment studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future motors and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or Contractor.

D. If applicable, include fault contribution of existing motors in the study. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141-1993.

B. Transformer design impedances shall be used when test impedances are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated
4. Source impedance data, including electric utility system and motor fault contribution characteristics
5. Tabulations of calculated quantities
6. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system.

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Notify Owner in writing, of existing, circuit protective devices improperly

rated for the calculated available fault current.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.

B. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the TCC graphs, where applicable:

1. Electric utility's overcurrent protective device
2. Medium voltage equipment overcurrent relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points, where applicable
9. Pertinent generator short-circuit decrement curve and generator damage point
10. The largest feeder circuit breaker in each motor control center and applicable panelboard.

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.5 ARC FLASH RISK ASSESSMENT

A. The arc flash risk assessment shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

C. The Arc-Flash Risk Assessment shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater

than 125 kVA where work could be performed on energized parts.

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for eachequipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

2.6 REPORT SECTIONS

A. Input data shall include, but not be limited to the following:

1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).
2. Transformer input data, including winding connections, secondary neutral- ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift.
3. Reactor data, including voltage rating, and impedance.
4. Generation contribution data, (synchronous generators and Utility), including short- circuit reactance (X"d), rated MVA, rated voltage, three-phase and single line- ground contribution (for Utility sources) and X/R ratio.
5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.

B. Short-Circuit Output Data shall include, but not be limited to the following reports:

1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated fault current magnitude and angle
    c. Fault point X/R ratio
    d. Equivalent impedance
2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated symmetrical fault current magnitude and angle
    c. Fault point X/R ratio
    d. Calculated asymmetrical fault currents
        1. Based on fault point X/R ratio
        2. Based on calculated symmetrical value multiplied by 1.6

3. Based on calculated symmetrical value multiplied by 2.7

e. Equivalent impedance

3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage
   b. Calculated symmetrical fault current magnitude and angle
   c. Fault point X/R ratio
   d. No AC Decrement (NACD) Ratio
   e. Equivalent impedance
   f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a symmetrical basis
   g. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a total basis

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:
   a. Current transformer ratio
   b. Current setting
   c. Time setting
   d. Instantaneous setting
   e. Recommendations on improved relaying systems, if applicable.
2. Circuit Breakers:
   a. Adjustable pickups and time delays (long time, short time, ground)
   b. Adjustable time-current characteristic
   c. Adjustable instantaneous pickup
   d. Recommendations on improved trip systems, if applicable.
      Incident energy and flash protection boundary calculations
      1. Arcing fault magnitude
      2. Protective device clearing time
      3. Duration of arc
      4. Arc flash boundary
      5. Working distance
      6. Incident energy
      7. Hazard Risk Category*
      8. Recommendations for arc flash energy reduction

*Applicable only when using the arc flash PPE category method.

PART 3 EXECUTION

3.1 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordinates Field adjustments to be completed by engineering service division of the equipment manufacturer under the Acceptance Testing contract.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

3.2 ARC FLASH WARNING LABELS

A. The contractor of the Arc Flash Risk Assessment shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.

C. The label shall include the following information, at a minimum:

1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category*
5. Incident energy
6. Working distance
7. Engineering report number, revision number and issue date.

*Applicable only when using the arc flash PPE category method.

D. Labels shall be machine printed, with no field markings.

E. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

1. For each 600, 480 and applicable 208 volt panelboard, one arc flash label shall be provided.
2. For each motor control center, one arc flash label shall be provided.
3. For each low voltage switchboard, one arc flash label shall be provided.
4. For each switchgear, one flash label shall be provided.
5. For medium voltage switches one arc flash label shall be provided

F. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing

3.3 ARC FLASH TRAINING

A. The contractor of the Arc Flash Risk Assessment shall train the owner's qualified electrical personnel of the potential arc flash risks associated with working on energized equipment (minimum of 4 hours).

3.4 ARC FLASH COORDINATION MEETING

A. Conduct an ARC Flash meeting with HRSD Electrical Personnel after equipment selection to discuss reporting format, guidelines, expectations, and defining responsibilities. This includes consultants, equipment manufacturers, and electrical contractors, etc.