COMPLETE REVISION
May 2018

Electrical

PIP ELSSG04
Automatic Transfer Systems for Secondary Selective Substations
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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1. **Scope**

This Practice describes minimum requirements for design, performance, inspection, testing, and documentation, for delayed transfer automatic transfer systems (ATS) for two-source secondary selective substations. ATS provides automatic restoration of bus voltage upon loss of one of the sources. This Practice also covers remote monitoring and control requirements. This Practice does not cover fast bus transfer or delayed in-phase transfer systems.

2. **References**

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 **Process Industry Practices (PIP)**
- PIP ELSSG01 - *Design and Fabrication of Low Voltage Metal-Enclosed AC Power Circuit Breaker Switchgear*
- PIP ELSSG02 - *Design and Fabrication of Medium Voltage Metal-Clad Switchgear above 1000 V to 38 kV*

2.2 **Institute of Electrical and Electronics Engineers (IEEE)**
- IEEE Std C37.2 - *IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations*

3. **Definitions**

*closed transition transfer:* A transfer system designed such that both sources of the secondary selective system are connected at the same time during power transfer. This results in the temporary paralleling of sources, and prevents a bus from being de-energized while switching sources. Also known as “make-before-break” operation.

*delayed in-phase transfer:* Type of open transition transfer system typically used when a fast transfer attempt fails (i.e., after approximately 10 cycles). The system waits for the next in-phase event to transfer (i.e., typically within 20 cycles).

*delayed transfer:* Type of open transition transfer system designed to wait for a predetermined time (i.e., typically greater than 20 cycles) or decay of bus voltage to a predetermined level after a bus power source is removed before connecting the bus to another source. This type of transfer is not intended to maintain process continuity; certain motor driven loads may necessitate restart of the motors on the bus. Also known as slow or long time transfer.

*fast bus transfer:* Type of open transition transfer system designed to prevent paralleling of both sources, but minimize the time to reclose and restore power (i.e., typically less than 10 cycles)

*open transition transfer:* A transfer system designed such that one main breaker of the secondary selective system is opened before the tie breaker closes, thereby permitting a bus to be de-energized during the switching process. Also known as “break-before-make” operation.

*owner:* The party who owns the facility wherein the automatic transfer system equipment shall be used.
purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner’s authorized agent.

secondary selective substation: A distribution system with two radial systems with a typically open secondary tie breaker or double tie breaker between them. The tie may be a cable between an extra breaker on each bus of two distant stations or a tie breaker between the buses of two stations located close together.

supplier: The party responsible for manufacturing, furnishing and/or installing the automatic transfer system equipment

system faults: Phase and ground faults where referenced in this Practice

4. Requirements

4.1 General

4.1.1 Unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet, the ATS component materials, wiring, and nameplate requirements shall be in accordance with this Practice and the switchgear Practices PIP ELSSG01 or PIP ELSSG02.

4.1.2 The ATS architecture shall be based on multifunctional devices IEEE Std C37.2 device number 11 multi-function relay (MFR), or a programmable logic controller (PLC) supported scheme as specified on the purchaser’s PIP ELSSG04D Data Sheet. This Practice is not intended for implementation with hardwired systems.

4.1.3 Where this Practice references a control switch associated with the ATS, the control switch functionality may be part of an MFR or PLC if the same degree of control capabilities is provided. Final implementation of control switches shall be agreed with owner before start of fabrication.

4.1.4 If an MFR is provided for both protection and control functions, the protection and control configurations should be developed concurrently to avoid creating two configuration files with the capability of one to overwrite the other.

4.1.5 MFR or PLC shall have an internal self check fault analysis system that verifies the software and hardware integrity of the device itself. A common, fail-safe alarm shall be provided to indicate a system failure for remote indication.

4.1.6 For normal conditions, secondary-selective system switchgear shall operate with the bus-tie circuit breaker (see 52T in Figure 1) open and both main breakers closed (see 52A and 52B in Figure 1). Where double bus-tie breakers are specified as indicated on the one line diagram, refer to Section 4.6 for operational description.

4.1.7 The ATS shall be designed with both manual and automatic modes of operation in accordance with Sections 4.3 and 4.4, respectively.

4.1.8 A separate and individually protected DC or redundant UPS AC control power circuit shall be provided to each incoming and bus-tie circuit breaker.

4.1.9 MFR or PLC control power shall be provided by separate and individually protected DC or redundant UPS AC control power circuits.
4.1.10 Detailed control and testing procedures shall be developed and submitted for owner approval before equipment manufacturing for new systems or before implementation on existing systems.

4.1.11 Design of the controls shall be logical and the controls shall be clearly labeled.

4.1.12 If indicated on the contract drawings or purchaser’s PIP ELSSG04D Data Sheet, a mimic diagram shall be provided on the front of the ATS equipment.

4.1.13 Event recording functionality shall be provided to facilitate analysis of system operation including failure of the ATS.

4.2 Operational Interlocks

4.2.1 Manual opening of an incoming line circuit breaker of the switchgear by means of the mechanical trip or breaker control switch shall not initiate the automatic closure of the bus-tie circuit breaker.

4.2.2 If the ATS “Not Ready” alarm is activated, the ATS system shall be disabled. See Section 4.8.3.

4.2.3 Synchronism check function shall interlock the manual transfer operation to:
   a. Prevent manual closed transition (i.e., parallel) operation if the sources are not synchronized
   b. Permit breaker closure by control switch if any two breakers are open

   Comment: If an additional power source is connected to a bus (e.g., connection to a generation source such as a stand-by generator), additional functionality may be required.

4.2.4 To prevent mis-operation of the ATS because of an under-voltage condition caused by a short circuit within a bus zone, over-current protection for each main breaker shall be hardwired to a lockout relay (LOR) ANSI/IEEE Device 86. An overcurrent trip by the MFR will operate the LOR. A contact from each 86 lockout relay shall be hardwired as a permissive in the close circuit for the tie breaker to block the ATS from automatic transfer until one of the following:
   a. Manually reset.
   b. Other alternate schemes for over-current protection if approved in writing by owner before start of manufacturing.

4.2.5 System faults that are not cleared by out-going secondary circuit protective devices shall open the incoming breaker (see 52-A or 52-B in Figure 1). The tie breaker shall remain open and the ATS shall be automatically locked out.

4.2.6 If a differential device (87B) detects a fault, the following shall occur:
   a. The ATS shall be blocked from operation.
   b. The automatic reset shall not be used.
   c. If a transformer or generator differential interlock (87T, 87G) is specified on purchaser’s PIP ELSSG04D Data Sheet, the ATS shall be blocked if a transformer or generator differential is initiated when one of the CT’s is on the load side of the main breaker. In this case the differential may detect a fault on a part of the bus.
4.2.7 For high resistance grounded systems, automatic and manual transfer or retransfer shall be prevented if a system ground fault is detected on both buses.

4.2.8 Potential voltage transformer fuse failure (VTFF) interlocks or other loss of potential voltage indication shall be provided to prevent false operation of the automatic transfer.

4.2.9 For a closed transition operation (see Section 4.3), an interlock with the following characteristics shall be provided:
   a. The time duration of the parallel condition shall be the shortest duration possible. The duration can be instantaneous (e.g., by monitoring the position of the breaker status contacts); however, if a time delay is required, a delay no greater than 2 seconds shall be implemented, unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet.
   b. Failure of any one control device (e.g., PLC, MFR, etc) shall not disable the interlock.
   c. The interlock shall only be implemented if all main and tie breakers are fully inserted in the operating position.

4.2.10 The system configuration shall include test switches to permit removal and/or testing of an MFR or PLC without initiating an automatic transfer operation.

4.2.11 Closing of the tie breaker during an automatic operation shall be blocked by one or both of the following interlocks:
   a. A residual voltage interlock reading the bus voltage.
      Comment: Once the respective bus main breaker opens, the interlock keeps the tie breaker from closing until the bus voltage decays to a predetermined level, typically 0.25 pu voltage.
   b. A timer that provides a delay after the main breaker opens.
      Comment: In certain applications (e.g., large motors with capacitors) the timer may need to be set to a relatively long time.

4.2.12 Unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet, both interlocks described in Section 4.2.11 shall be cleared to close the tie breaker. See section 4.4 and Figure 3.

4.2.13 The ATS system shall be disabled if either of the main breakers fails to open on command or the tie breaker fails to open on command, see Figures 3 and 4.

4.3 Manual Operation

4.3.1 Manual operation shall permit switching of the substation breakers in either an open or closed transition mode.

4.3.2 For an open transition operation, the ATS shall permit dead-bus closing of the main breakers; however, interlocks related to fault detection shall remain operational.

4.3.3 For a closed transition operation, the ATS interlocks shall be in service except for the residual voltage interlock and transfer timer.
4.3.4 Execution of the closed transition requires one of the breakers to be opened after the system is paralleled. Therefore, the ATS shall include a breaker selector switch with the following capabilities:

a. Controls to open the selected breaker once the system is paralleled in accordance with Section 4.2.9.

b. Controls to prevent reclosing of the selected breaker.

c. Only operational if the system is being manually operated.

4.3.5 Except for the case in Section 4.3.6, manual open transition operation shall be permitted without the automatic operation components. Therefore the following shall apply:

a. A failure of the PLC shall not prevent manual and safe operation of the switchgear.

b. Failure of an MFR used for the dual purpose of protection and control shall not cause loss of manual transfer control.

4.3.6 Failure of a PLC or MFR while protecting, or executing an interlock for, a specific breaker shall result in a ‘block close’ of that breaker.

4.3.7 An instruction nameplate shall be provided that shows step-by-step instructions to initiate manual transfer operations.

4.4 Automatic Operation

4.4.1 Automatic transfer shall only be permitted if the ATS is in the automatic mode and the system is in normal configuration (i.e., all breakers inserted in operating position with main breakers closed and the tie breaker open).

4.4.2 Loss of voltage for a predetermined time on either incoming Circuit A or Circuit B (see Figure 1) shall be managed as follows:

a. Incoming breaker 52A or 52B, respectively, shall open and, if interlocks permit, the tie-breaker 52T shall close.

b. An adjustable time delay from 0 to 10 seconds shall be provided to delay initiation of the ATS upon detection of the loss of voltage on only one of the two incoming circuits.

4.4.3 If voltage on both Circuit A and Circuit B is lost, incoming breakers 52A and 52B shall remain closed and tie-breaker 52T shall remain open.

4.4.4 If voltage of Circuit A is lost, the main breaker shall open after a predetermined time; however, the ATS shall block the tie breaker from closing if the voltage on Circuit B is below acceptable levels. Likewise, transfer from Circuit B to A shall be blocked in the same manner.

4.4.5 The tie breaker shall remain open if either incoming breaker (52A or 52B) is opened by its protective device or control switch.

4.4.6 Unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet, after an automatic operation, the switchgear shall be manually restored to the normal operational position.
4.5 **System Security**

4.5.1 System devices that execute control of the system shall be provided with security measures to avoid inadvertent or malicious tampering as specified on purchaser’s PIP ELSSG04D Data Sheet (e.g., MFR’s / PLC’s may have the capability of password or key-switch protection).

4.5.2 Systems interconnected outside the substation (e.g., connections to plant computer networks) shall be capable of blocking unauthorized external control.

4.5.3 System security shall be reviewed with owner and shall be consistent with existing security procedures.

4.6 **Double Tie-Breaker Construction**

4.6.1 If double tie breakers are provided, the operation of the tie breaker system shall be in accordance with this Practice.

4.6.2 One tie breaker shall be designated as the automatically controlled tie breaker. The other tie breaker shall be manually operated only.

4.6.3 The ATS shall control the automatically operated tie breaker only.

4.6.4 Tie breakers shall be interlocked such that the automatically operated tie breaker can only be closed once the manually operated tie breaker is closed. Execution of this interlock shall only be permitted if both breakers are fully connected.

4.6.5 For normal operation, the automatically controlled tie breaker shall normally be open, and the manually controlled tie breaker shall normally be closed.

4.6.6 Both tie breakers shall be tripped by operation of the protection system.

4.7 **Arrangement of Controls**

4.7.1 ATS controls shall be arranged in an understandable manner that displays the physical arrangement of the switchgear and provides all measurements and indications required to operate the system.

4.7.2 Centralized ATS controls shall be arranged such that an operator can maintain sight of all critical indications and measurements while operating the system. The following capabilities shall be provided:

   a. All measurements, indications, and control devices can be interpreted and operated while an operator stays in place.
   
   b. Unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet, the height and configuration of controls shall be between 48 inches (122 cm) and 60 inches (152 cm). Indications and measurements shall not be located greater than 78 inches (198 cm) above grade.

4.7.3 Mimic diagrams, controls, indications, and measurements shall be integrated to provide a complete system.

4.7.4 As a minimum, the following voltage indications shall be provided:

   a. Line voltage on each source
   
   b. Bus voltage on each bus
4.7.5 As a minimum, the following controls shall be provided:
   a. Breaker control switches for each main and tie breaker
   b. Breaker-to-trip selector switch
   c. Unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet, automatic/manual selector switch

4.7.6 If specified on purchaser’s PIP ELSSG04D Data Sheet, the ATS operator controls, voltage indications, and control indicator lights shall be provided on a remote mimic/control panel.

   Comment: Typically used when locating controls outside of the arc flash protection boundary if non-arc resistant equipment is used.

4.8 Alarms and Indication

4.8.1 As a minimum, the following control indicator lights shall be provided near the ATS control switches/panel:
   a. ATS Ready to Transfer
   b. Sources In Sync indication for each breaker
   c. Open and close breaker position for each main and tie breaker

4.8.2 As a minimum, the following alarms for remote indication shall be provided with the ATS.
   a. ATS Not Ready, see Section 4.8.3.
   b. Abnormal System Configuration, initiated if the system is not in the normal configuration with both mains closed and the tie breaker open, and if any of the main and tie breakers are not fully installed in the connected position
   c. ATS Failure, from any mode of failure (i.e. MFR or PLC self-check system, loss of communication between protective devices, etc.)
   d. DC or redundant UPS AC Control Power Supply Failure, from individual breaker control schemes or control device power supply

4.8.3 ATS Not Ready alarm shall be initiated and the ATS Ready to Transfer indication shall go out if any of the following events occurs:
   a. Alternate source voltage not available (i.e., outside acceptable range or sources not in synchronism)
   b. Fault detected (i.e., system blocked by time-overcurrent or differential device)
   c. Control device failure (e.g., MFR, PLC)
   d. DC or redundant UPS AC power supply failure
   e. Loss of Line potential transformer (PT) alarm
   f. Main breaker open or not connected
   g. Tie breaker closed or not connected
4.8.4 A form “c” alarm contact shall be provided for annunciating each of the alarm conditions listed in Section 4.8.2 to owner’s alarm-monitoring system. Unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet, alarm contacts shall have a minimum rating of 2A at 120VAC and 125VDC.

4.8.5 The ATS shall have communications options capabilities as specified on purchaser’s PIP ELSSG04D Data Sheet.

4.9 Example Diagrams

4.9.1 One-Line Diagram

4.9.1.1 A simplified protective relay one-line diagram is shown in Figure 1.

4.9.1.2 Implementation using PLC or certain MFR can cause differences in system configurations.

4.9.1.3 Detailed protective relay one-line diagrams should show more complete and implementation-specific information.

![Figure 1. Example of Protective Relay One-Line Diagram](image)

4.9.2 Block Diagrams

4.9.2.1 Figure 2 shows a legend of the symbols used in the example block diagrams.

4.9.2.2 The block diagrams in Figures 3 and 4 show general configurations of the ATS function. All possible ATS configurations are not shown in these block diagrams.

4.9.2.3 Detailed configurations shall be agreed and approved by the owner.
**Legend for Logic Diagrams**

- **Decision diamond** – Yes or No output decided for ‘description’
- **Status block** – describes a situation or status
- **Timer** – operation as described
- **AND gate** – If all inputs are true, output is true
- **OR gate** – If any input is true, output is true
- **Action diamond** – action as described due to inputs results in output indicated

*Figure 2. Legend for Block Diagrams*
ATS IN NORMAL CONDITION - BOTH MAIN BREAKERS CONNECTED AND CLOSED, TIE BREAKER CONNECTED AND OPEN, NO ALARMS ALL VOLTAGE AND CURRENTS WITHIN LIMITS

Figure 3. Example Block Diagram – Automatic Transfer Basic Logic
ATS IN NORMAL CONDITION - BOTH MAIN BREAKERS CONNECTED AND CLOSED, TIE BREAKER CONNECTED AND OPEN, NO ALARMS

- ALL VOLTAGE AND CURRENTS WITHIN LIMITS

- **Breaker Failure**
  - YES
  - NO

- **Main Over Current trip**
  - YES
  - NO

- **Main Instantaneous OC pick-up**
  - YES
  - NO

- **Bus Differential zone trip**
  - YES
  - NO

- **TR Differential zone trip**
  - YES
  - NO

- **Auto/Manual Switch in Manual Position**
  - AND

- **Auto/Manual Switch is optional**

- **Bus tie sync check OK**

- **Tie-Breaker Control Switch - Close Command**

- **ATs not ready alarm - disable automatic controls**

- **Optional 0-2 second time delay**

- **Close Tie Breaker**

- **TDPU**

- **Breaker To Trip Selector**

- **Open Main A OR Open Main B**

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4.10 **Nameplates**

4.10.1 Nameplates shall be provided in accordance with this Practice and the requirements in the switchgear Practices *PIP ELSSG01* or *PIP ELSSG02* referenced on purchaser’s *PIP ELSSG04D* Data Sheet.

4.10.2 Permanent engraved lamicoid nameplates shall be provided identifying the control devices, voltage indications and control indicator lights of the ATS.

4.10.3 Stand-alone ATS panels shall include a stainless steel nameplate identifying the manufacturer, year of manufacture, and shop order number.

4.10.4 If a mimic diagram is specified on the purchaser’s *PIP ELSSG04D* Data Sheet, the diagram shall be provided as follows:
a. As a minimum, the diagram shall show the configuration of the system, buswork, circuit breakers, supply sources, load designations, voltage transformers, and current transformers.

b. Breaker control switches shall be beside the breaker symbol.

c. Devices shall be labeled using engraved lamicoid.

d. The mimic buswork and components shall be attached with stainless steel screws.

4.11 Inspection and Testing

4.11.1 Inspection and testing shall be performed in accordance with this Practice and the requirements in the switchgear Practices PIP ELSSG01 or PIP ELSSG02 referenced on the purchaser’s PIP ELSSG04D Data Sheet.

4.11.2 Components of the ATS shall be tested in accordance with specific component requirements.

4.11.3 The ATS shall be functionally tested to prove the required operation sequences, interlocks and adequacy of control arrangement.

4.11.4 Functional tests shall include automatic operation and re-transfer to normal plus manual operation and re-transfer to normal.

4.11.5 If the ATS controls form part of the switchgear assembly, the switchgear shall be electrically and mechanically assembled into one single line-up before final testing.

4.11.6 If the ATS controls are remote from the switchgear, the controls may be tested separately from the switchgear. The test setup shall clearly represent and properly simulate all elements not on the control panel including the loop impedance to remote devices.

4.11.7 The functional test procedure shall be provided to the purchaser for approval before final testing.

4.11.8 The purchaser shall be notified two weeks in advance of testing. If witness testing has been specified on purchaser’s PIP ELSSG04D Data Sheet, the notification shall be provided only after the supplier’s pre-witness tests have been completed. Notification of witness testing shall include a list of tests and acceptable range of values.

4.11.9 A copy of the installation, operating, and maintenance instruction book, including protective relay instructions, shall be on the test floor at time of purchaser’s witness testing of equipment. A complete unmarked set of final full size drawings shall be available for use by purchaser’s inspector at time of witness testing.

4.11.10 The purchaser or the purchaser’s representative reserves the right to inspect and observe the tests at the supplier’s shop.

4.12 Documentation

4.12.1 Documentation Content

4.12.1.1 Block diagrams, logic diagrams, and schematics shall be provided.
4.12.1.2 Logic scheme drawings shall include the following information as a minimum:
   a. Complete logic having all elements identified with unique numbers.
   b. Hardware identified with item numbers corresponding to bill of materials.
   c. Contact position of all devices (i.e., hardware and software) in shelf (i.e., normally de-energized) position.
   d. Definitions table of all hardware and virtual devices, variables, inputs and outputs.
   e. Cross-reference to bill of materials and other drawings

4.12.1.3 All control programs (e.g., MFR settings, MFR or PLC logic, etc.) shall be provided to owner.

4.12.1.4 Any other software required to program or communicate with devices that are part of the ATS shall be provided to owner.

4.12.2 Drawing and Data Requirements

4.12.2.1 One reproducible set of drawings shall be provided plus the specified number of copies of all documentation and operating manuals as specified on purchaser’s PIP ELSSG04D Data Sheet.

4.12.2.2 Unless otherwise specified on purchaser’s PIP ELSSG04D Data Sheet, format for reproducible drawings shall be DWG electronic format.

4.12.2.3 Format for operating manuals shall be PDF.

4.12.2.4 Device software shall be provided in native format on electronic media approved by the purchaser.

4.12.2.5 Drawings and data requirements shall be as shown in Table 1.

4.13 Shipment

Preparations for shipment shall be in accordance with the requirements in the switchgear Practices PIP ELSSG01 or PIP ELSSG02 referenced on purchaser’s PIP ELSSG04D Data Sheet.

4.14 Conflict Resolution

Any conflicts between the referenced documents shall be identified in writing to the purchaser for resolution. If resolving conflicts, the following order of precedence shall apply:

- Purchase Order
- One-line diagram and associated documents
- PIP ELSSG04D Data Sheet
- This Practice, PIP ELSSG04
### Table 1. Documentation Requirements

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<th>B For Review</th>
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<td>Equipment drawings, showing floor plans, front view elevations, relay and control device panel layouts, typical sectional views. Drawings shall show all locations of all equipment and devices.</td>
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<td>Installation drawings, showing dimensions and weights of all shipping sections and location and type of all interconnections between shipping splits</td>
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<td>Connection wiring diagrams for all electrical equipment</td>
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Notes:
A. These documents shall be provided with proposal.
B. These documents shall be provided for purchaser’s review and authorization to proceed before fabrication.
C. These documents shall be provided as part of the final certified document submittal.
D. As-built documents shall be provided within 2 weeks following shipment.