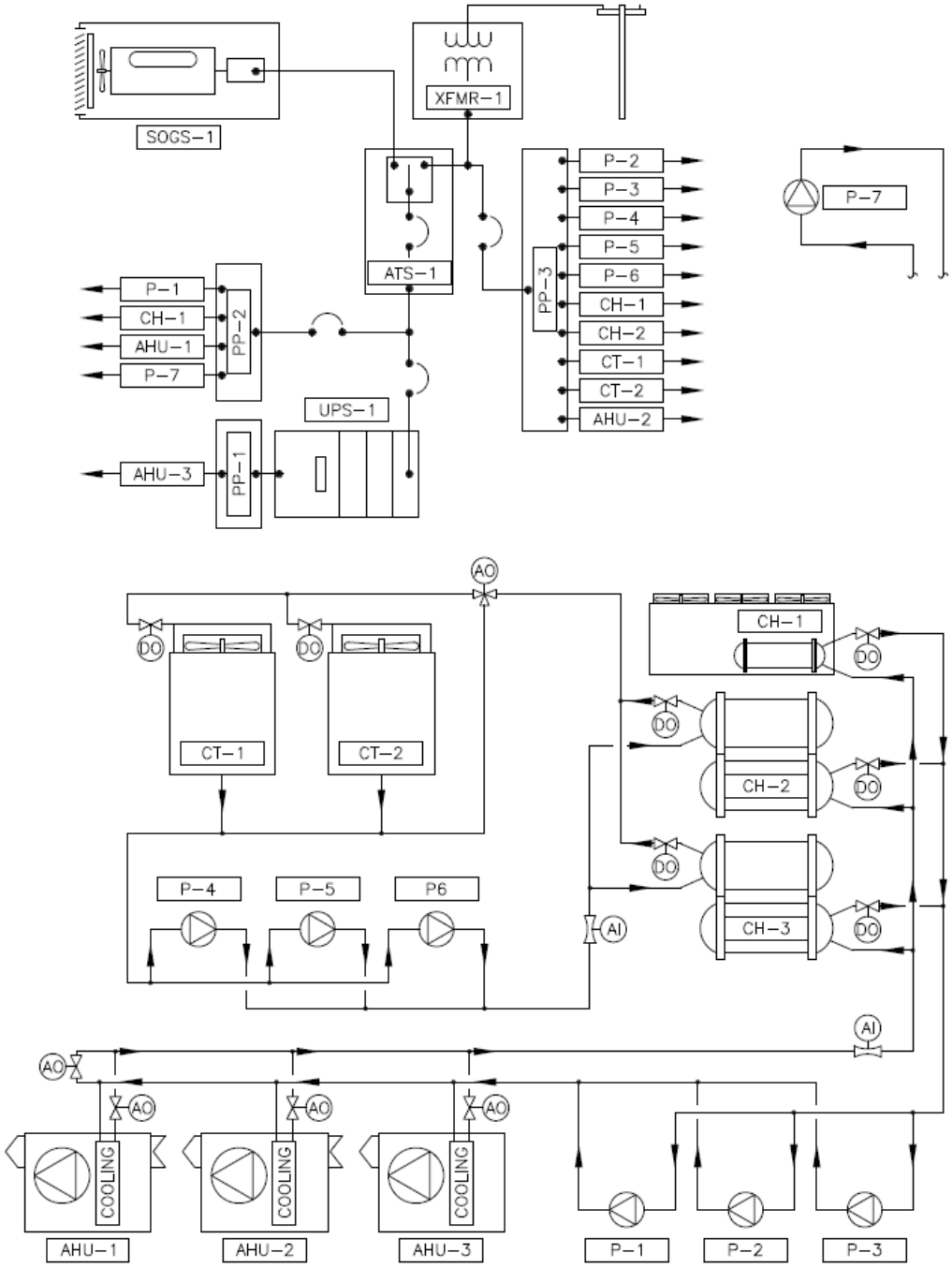
ELECTRICAL – HVAC – FIRE PROTECTION

1. INTRODUCTION

This sample integrated system test (IST) checklist is for the interaction between hypothetical electrical; heating, ventilation, and air-conditioning (HVAC); and fire protection systems.

The following system diagram is intended to communicate information about these hypothetical systems and is not required to be included as part of any IST.



2. NOTABLE SYSTEM FEATURES

The purpose of this section is to identify notable systems features to facilitate an understanding of systems interaction.

Notable electrical system features

a. Critical power panel PP-1 is selected to service:
   - Air handling unit AHU-3
   - HVAC control system’s Operator work station
   - HVAC system local control panel LCP-1 serving air handling unit AHU-3

b. Sub-critical power panel PP-2 is selected to service:
   - Distribution pump P-1
   - Air-cooled chiller CH-1
   - Air handling unit AHU-1
   - HVAC system local control panel LCP-2 serving distribution pump P-1, air-cooled chiller CH-1, and air handling unit AHU-1
   - Fire pump P-7

c. Non-critical power panel PP-3 is selected to service:
   - Distribution pumps P-2 and P-3
   - Condenser water pumps P-4, P-5, and P-6
   - Water-cooled chillers CH-1 and CH-2
   - Cooling towers CT-1 and CT-2
   - Air handling unit AHU-2
   - HVAC system local control panel LCP-3 serving all HVAC equipment not served by LCP-1 and LCP-2

d. Single operation generator set SOGS-1 is selected meet electrical demand of critical power panel PP-1 and sub-critical power panel PP-2.

e. Automatic transfer switch ATS-1 is selected to transfer electrical service between preferred power and single operation generator set SOGS-1 to service uninterruptible power supply UPS-1 and sub-critical power panel PP-2.

f. Uninterruptible power supply UPS-1 is selected meet electrical demand of power panel PP-1.

Notable HVAC system features

a. Uninterrupted airflow from air handling unit AHU-3 is accomplished by its electrical service being through uninterruptable power supply UPS-1 and semi-disrupted temperature control is accomplished during transition of primary utilities by the chilled water system’s thermal inertia.

b. Semi-disrupted airflow from air handling unit AHU-1 is accomplished by its electrical service being from both preferred power and single operation generator set SOGS-1. During transition of electrical service from preferred power to single operation generator set SOGS-1, air handling unit AHU-1 is disabled and re-enabled when electrical service is available from SOGS-1.

c. Upon loss of electrical service from preferred power, cooling load is transferred from water-cooled chillers CH-2 and CH-3 to air-cooled chiller CH-1.

d. Each water-cooled chiller CH-2 and CH-3 is selected to meet 50-percent of total facility cooling demand.

e. Air-cooled chiller CH-1 is intended for use upon loss of electrical service from preferred power or during failure of both water-cooled chillers CH-2 and CH-3.
f. Air-cooled chiller CH-1 is selected to meet 100-percent of critical area and sub-critical area cooling demands.
g. Each chilled water distribution pump P-1 through P-3 is selected to meet requirements of a single water-cooled chiller CH-2 and CH-3 yielding one redundant pump.
h. Each condenser water pump P-4 through P-6 is selected to meet requirements of a single chiller CH-2 and CH-3 yielding one redundant pump.
i. Air handling unit AHU-1 is selected to meet 100-percent of sub-critical area cooling demand.
j. Air handling unit AHU-2 is selected to meet 100-percent of non-critical area cooling demand.
k. Air handling unit AHU-3 is selected to meet 100-percent of critical area cooling demand.

Notable fire protection system features

a. Fire pump P-7 is selected to meet 100-percent of facility demand yielding no redundant pump.

3. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this section is to identify conclusions and recommendations based on observations of interconnected system operation.

It is concluded that these systems [do / do not perform] in accordance with contract requirements.

It is recommended that these [systems be / not be] accepted by the government.

The following systems enhancements are recommended:

4. TEST CONDITIONS

The purpose of this section is to identify conditions occurring at time of testing.

Test date: _____

Test begin time: _____

Test end time: _____

5. EQUIPMENT IDENTIFICATION

The purpose of this section is to identify equipment included in this system.

Single operation generator set: SOGS-1
Uninterruptible power supply: UPS-1
Automatic transfer switch: ATS-1
Chiller (water cooled): CH-1
Chiller (water-cooled): CH-2
Chiller (air-cooled): CH-3
Cooling tower: CT-1
Cooling tower: CT-2
Distribution pump: P-1
Distribution pump: P-2
Distribution pump: P-3
Condenser water pump: P-4
Condenser water pump: P-5
Condenser water pump: P-6
Air handling unit (sub-critical): AHU-1
Air handling unit (non-critical): AHU-2
Air handling unit (critical): AHU-3
Fire pump: P-7

6. ATTENDEES

The purpose of this section is to identify persons present during integrated systems testing.

ATTENDEES			
REPRESENTING	**NAME**	**COMPANY**	**TELEPHONE NUMBER**
Electrical Commissioning Specialist:			
Mechanical Commissioning Specialist:			
Fire Protection Commissioning Specialist:			
Owner’s Representative:			
Electrical Contractor:			
Mechanical Contractor:			

ATTENDEES			
REPRESENTING	**NAME**	**COMPANY**	**TELEPHONE NUMBER**
Controls Contractor:			
Fire Protection Contractor:			

7. PERFORMANCE VERIFICATION TEST CHECKLISTS

The purpose of this section is to identify dates of completion and approval, as well as approving authority of relevant functional performance test (FPT) checklists.

FUNCTIONAL PERFORMANCE TEST CHECKLIST	COMPLETION DATE	APPROVAL DATE	APPROVING CONTRACTOR QUALITY CONTROL MANAGER
Electrical preferred / alternate power:			
Water-cooled chilled water plant:			
Air handing unit AHU-1:			
Air handing unit AHU-2:			
Air handing unit AHU-3:			
Fire pump system:			

8. SYSTEM OPERATION OBSERVATIONS

The purpose of this section is to document results from multi-system-based testing with loss of preferred power, electrical service from single operation generator set, and return of preferred power.

Testing is grouped by discipline as follows to maximize testing efficiency:

a. Electrical systems.

b. HVAC systems.

c. Fire protection systems.

Control algorithms and operation modes are tested as part of respective functional performance tests (FPT’s) prior to performing this integrated system test (IST).

Because control algorithm and operation mode observations were physically made as part of respective FPT, system responses are observed from Operator workstation where applicable unless indicated otherwise.

The following electrical systems testing is provided in the matrix below:

a. Test preparation.
b. Preferred power loss.
c. Electrical service from single operation generator set.
d. Preferred power restoration.

The following HVAC systems testing is provided in the matrix below:

a. Test preparation.
b. Preferred power loss.
c. Electrical service from single operation generator set.
d. Preferred power restoration.

The following fire protection systems testing is provided in the matrix below:

a. Test preparation.
b. Preferred power loss.
c. Electrical service from single operation generator set.
d. Preferred power restoration.

Abbreviations used in the matrix below include:

a. Test Method:
   Manipulated parameter(s) necessary to produce expected system response.
b. Expected Response:
   Anticipated system reaction to manipulated parameter(s).
c. Comments:
   Commissioning specialist's issues related to observations.
d. Pass / Fail:
   P - Expected response is observed without issues of concern.
   F - Expected response is not observed resulting in noted issues of concern.
e. Miscellaneous:
   CS - Control signal.

ELECTRICAL SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Test Preparation				
01	To prepare for system response: • Observe system status	Single operation generator set SOGS-1 status confirmed on stand-by	CS of _____	
02		Uninterruptable power supply UPS-1 status confirmed on stand-by	CS of _____	
03		Automatic transfer switch ATS-1 status confirmed on preferred power	CS of _____	

ELECTRICAL SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Preferred Power Loss Design Control Sequence: Upon detection of loss of preferred power, the electrical system shall: • Automatic transfer switch ATS-1 transmits signal for loss of electrical service from preferred power • Automatic transfer switch ATS-1 transmits start signal to single operation generator set SOGS-1 • Single operation generator set SOGS-1's speed increased to normal operating speed • Single operation generator set SOGS-1 transmits signal for usable voltage				
04	To observe system response to preferred power loss: • Receive Mechanical Commissioning Specialists' ready status • Receive Fire Protection Commissioning Specialists' ready status • Initiate loss of preferred power • Observe system status	Mechanical Commissioning Specialists' ready status received		
05		Fire Protection Commissioning Specialists' ready status received		
06		Automatic transfer switch ATS-1 transmits signal for loss of electrical service from preferred power	CS of _____	
07		Automatic transfer switch ATS-1 transmits start signal to single operation generator set SOGS-1	CS of _____	
08		Single operation generator set SOGS-1's speed increases to normal operating speed		
09		Automatic transfer switch ATS-1 receives signal for usable voltage from single operation generator set SOG-1	CS of _____	
Electrical Service From Single Operation Generator Set Design Control Sequence: Upon detection of electrical service from single operation generator set SOGS-1, the electrical system shall: • Automatic transfer switch ATS-1 switches source of electrical service to single operation generator set SOGS-1 • Automatic transfer switch ATS-1 transmits signal for electrical service from single operation generator set SOGS-1				
10	To observe system response to electrical service from single operation generator set SOGS-1:	Automatic transfer switch ATS-1 transfer switch ATS-1 switches source of electrical service to single operation generator set SOGS-1		

ELECTRICAL SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
11	• Observe system status	Automatic transfer switch ATS-1 transmits signal for electrical service from single operation generator set SOGS-1	CS of _____	
Preferred Power Restoration Design Control Sequence: Upon detection of restoration of preferred power, the electrical system shall: • Automatic transfer switch ATS-1 detects preferred power availability • Automatic transfer switch ATS-1 switches source of electrical service to preferred power • Automatic transfer switch ATS-1 transmits signal for electrical service from preferred power • Automatic transfer switch ATS-1 transmits signal to stop single operation generator set SOG-1 • Single operation generator set SOGS-1 stops				
12	To observe system response to restoration of preferred power: • Receive Mechanical Commissioning Specialists' ready status • Receive Fire Protection Commissioning Specialists' ready status • Restore normal power • Observe system status	Mechanical Commissioning Specialists' ready status received		
13		Fire Protection Commissioning Specialists' ready status received		
14		Automatic transfer switch ATS-1 detects preferred power availability		
15		Automatic transfer switch ATS-1 switches source of electrical service to preferred power		
16		Automatic transfer switch ATS-1 transmits signal for electrical service from preferred power		
17		Automatic transfer switch ATS-1 transmits signal to stop single operation generator set SOG-1		
18		Single operation generator set SOGS-1 stops		
19	Release all overrides	System returns to pre-test conditions		

HVAC SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Test Preparation				
01	To prepare for systems response: • Initiate all air handling unit active status • Initiate cooling load such that all water-cooled chillers are active • Take no action until stable system operation • Observe systems statuses • Communicate Mechanical Commissioning Specialists' ready status for next stage of testing to Electrical Commissioning Specialist	Chiller CH-1 status confirmed active	CS of _____	
02		Chiller CH-2 status confirmed active	CS of _____	
03		Chiller CH-3 status confirmed inactive	CS of _____	
04		Cooling tower CT-1 status confirmed active	CS of _____	
05		Cooling tower CT-2 status confirmed active	CS of _____	
06		Distribution pump (___) status confirmed active	CS of _____	
07		Distribution pump (___) status confirmed active	CS of _____	
08		Distribution pump (___) status confirmed active	CS of _____	
09		Condenser water pump (___) status confirmed active	CS of _____	
10		Condenser water pump (___) status confirmed active	CS of _____	
11		Condenser water pump (___) status confirmed inactive	CS of _____	
12		Air handling unit AHU-1 status confirmed active	CS of _____	
13		Air handling unit AHU-2 status confirmed active	CS of _____	
14		Air handling unit AHU-3 status confirmed active	CS of _____	
15		HVAC control system's Operator work station confirmed operable		

HVAC SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
16		Communicate ready status for next stage of testing to Electrical Commissioning Specialist		

Preferred Power Loss

Design Control Sequence:

Upon detection of loss of preferred power during occupied period, the HVAC control system shall:

- Receive signal for loss of electrical service from preferred power
- Maintain air-cooled chiller CH-1 inactive status
- Disable / maintain inactive status of water-cooled chiller CH-2
- Disable / maintain inactive status of water-cooled chiller CH-3
- Disable / maintain inactive status of cooling tower CT-1
- Disable / maintain inactive status of cooling tower CT-2
- Disable / maintain inactive status of distribution pump P-1
- Disable / maintain inactive status of distribution pump P-2
- Disable / maintain inactive status of distribution pump P-3
- Disable / maintain inactive status of condenser water pump P-4
- Disable / maintain inactive status of condenser water pump P-5
- Disable / maintain inactive status of condenser water pump P-6
- Disable / maintain inactive status of air handling unit AHU-1
- Disable / maintain inactive status of air handling unit AHU-2
- Maintain air handling unit AHU-3 active status

17	To observe system response to preferred power loss: • Observe system response upon loss of preferred power	Signal for loss of electrical service from preferred power received	CS of _____	
18		Air-cooled chiller CH-1 inactive status maintained	CS of _____	
19		Water-cooled chiller CH-2 disabled / inactive status maintained	CS of _____	
20		Water-cooled chiller CH-3 disabled / inactive status maintained	CS of _____	
21		Cooling tower CT-1 disabled / inactive status maintained	CS of _____	
22		Cooling tower CT-2 disabled / inactive status maintained	CS of _____	
23		Distribution pump P-1 disabled / inactive status maintained	CS of _____	

HVAC SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
24		Distribution pump P-2 disabled / inactive status maintained	CS of _____	
25		Distribution pump P-3 disabled / inactive status maintained	CS of _____	
26		Condenser water pump P-4 disabled / inactive status maintained	CS of _____	
27		Condenser water pump P-5 disabled / inactive status maintained	CS of _____	
28		Condenser water pump P-6 disabled / inactive status maintained	CS of _____	
29		Air handling unit AHU-1 disabled	CS of _____	
30		Air handling unit AHU-2 disabled	CS of _____	
31		Air handling unit AHU-3 active status maintained without disruption	CS of _____	
32		HVAC control system’s Operator work station confirmed operable		

HVAC SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Electrical Service From Single Operation Generator Set Design Control Sequence: Upon detection of electrical service from single operation generator set SOGS-1 during occupied period, the HVAC control system shall: • Receive signal for electrical service from single operation generator set SOGS-1 • Command air-cooled chiller CH-1's evaporator isolation valve to its 100-percent open position • Enable distribution pump P-1 • Take no action for a two-minute period • Enable air-cooled chiller CH-1 • Maintain water-cooled chiller CH-2 inactive status • Maintain water-cooled chiller CH-3 inactive status • Maintain cooling tower CT-1 inactive status • Maintain cooling tower CT-2 inactive status • Maintain distribution pump P-2 inactive status • Maintain distribution pump P-3 inactive status • Maintain condenser water pump P-4 inactive status • Maintain condenser water pump P-5 inactive status • Maintain condenser water pump P-6 inactive status • Enable air handling unit AHU-1 • Maintain air handling unit AHU-2 inactive status • Maintain air handling unit AHU-3 active status				
33	To observe system response: • Observe system status • Communicate Mechanical Commissioning Specialists' ready status for next stage of testing to Electrical Commissioning Specialist	Signal for electrical service from single operation generator set SOGS-1 received	CS of _____	
34		Air-cooled chiller CH-1's evaporator isolation valve commanded to its 100-percent open position	CS of _____	
35		Distribution pump P-1 enabled	CS of _____	
36		Two-minute period passes without control system action		
37		Water-cooled chiller CH-1 enabled	CS of _____	
38		Water-cooled chiller CH-2 inactive status maintained	CS of _____	
39		Water-cooled chiller CH-3 inactive status maintained	CS of _____	
40		Cooling tower CT-1 inactive status maintained	CS of _____	

HVAC SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
41		Cooling tower CT-2 inactive status maintained	CS of _____	
42		Distribution pump P-2 inactive status maintained	CS of _____	
43		Distribution pump P-3 inactive status maintained	CS of _____	
44		Condenser water pump P-4 inactive status maintained	CS of _____	
45		Condenser water pump P-5 inactive status maintained	CS of _____	
46		Condenser water pump P-6 inactive status maintained	CS of _____	
47		Air handling unit AHU-1 enabled	CS of _____	
48		Air handling unit AHU-2 inactive status maintained	CS of _____	
49		Air handling unit AHU-3 active status maintained	CS of _____	
50		Failed pump P-7 alarm initiated at Operator workstation		

Preferred Power Restoration

Design Control Sequence:

Upon detection of restoration of preferred power during occupied period, the HVAC control system shall:

- Receive signal for electrical service from preferred power
- Initiate chilled water plant activation operation mode
- Take no action for a thirty-minute period
- Disable air cooled chiller CH-1
- Take no action for a two-minute period
- Command air-cooled chiller CH-1's evaporator isolation valve to its 0-percent open position
- Maintain air handling unit AHU-1 active status
- Enable air handling unit AHU-2
- Maintain air handling unit AHU-3 active status

51	To observe system response:	Signal for electrical service from preferred power received	CS of _____	

HVAC SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
52	• Observe system status • Communicate Mechanical Commissioning Specialists' completion of testing to Electrical Commissioning Specialist	Chilled water plant activation operation mode initiated	CS of _____	
53		Thirty-minute period passes without control system action		
54		Air-cooled chiller CH-1 disabled	CS of _____	
55		Two-minute period passes without control system action		
56		Air-cooled chiller CH-1's evaporator isolation valve commanded to its 0-percent open position	CS of _____	
57		Air handling unit AHU-1 active status maintained	CS of _____	
58		Air handling unit AHU-2 enabled	CS of _____	
59		Air handling unit AHU-3 active status maintained	CS of _____	
60		Mechanical Commissioning Specialists' completion of testing communicated		
61	Release all overrides	System returns to pre-test conditions		

FIRE PROTECTION SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Test Preparation				
01	To prepare for system response: • Initiate sprinkler system water flow • Observe system status	Fire pump P-7 status confirmed active		
02		Communicate ready status for next stage of testing to Electrical Commissioning Specialist		
Preferred Power Loss Design Control Sequence: Upon detection of loss of preferred power during occupied period, the fire protection system shall: • Transmit failed pump P-7 alarm status				
03	To observe system response: • Observe system status	Failed pump P-7 alarm status transmitted	CS of _____	
Electrical Service From Single Operation Generator Set Design Control Sequence: Upon detection of electrical service from single operation generator set SOGS-1, the fire protection system shall: • Enable fire pump P-7				
04	To observe system response: • Observe system status	Pump P-7 enabled	CS of _____	
Preferred Power Restoration Design Control Sequence: Upon detection of restoration of preferred power, the fire protection system shall: • Maintain fire pump P-7 active status				
05	To observe system response: • Observe system status • Communicate Fire Protection Commissioning Specialists' completion of testing to Electrical Commissioning Specialist	Fire pump P-7 active status maintained	CS of _____	
06		Fire Protection Specialists' completion of testing communicated		
07		System returns to pre-test conditions		

-- End of Test --