

IMPACT ENGINEERING, INC.

AIRPORT OFFICE BUILDING

**Smoke Control System
Testing Procedures Manual**

September 10, 2016

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DENVER INTERNATIONAL AIRPORT – AIRPORT OFFICE BUILDING

SMOKE CONTROL SYSTEM TESTING QUALIFICATION

In accordance with the Denver Building Code -- Prior to acceptance testing of the smoke control systems, a Registered Professional Engineer, licensed in the State of Colorado, shall certify to the Building Inspection Division and the Fire Prevention Bureau that the entire smoke control system has been tested in accordance with its design, plans, specifications and the Denver Building Code.

It should be recognized that initial or annual performance tests, such as those conducted on this project, do not necessarily guarantee that the systems will perform in a similar manner under actual fire conditions. It is possible that component failure, due to normal wear and tear, vandalism or indeterminate causes, could occur immediately after the initial or annual testing.

The data, conclusions, and opinions presented in this report are based solely on the observations and information collected on the dates of the testing. Therefore, the testing agency and its employees will not offer any guarantees, warranties, or certifications relating to the subsequent performance of the life safety systems installed on this project.



Seal

Brian Zimmerman

Professional Engineer's Signature

PROCEDURES**A. SMOKE CONTROL SYSTEM TESTING AND OBSERVATIONS - GENERAL**

The Denver International Airport – Airport Office Building will have an electrically supervised addressable fire management system. The system shall include: Fire Department Operations Center Color Graphics Panel (CGP); Fire Alarm Graphic Annunciation Panels (GAP); Fire Alarm Master Panel (FAMP); and Fire Alarm Remote Control Panels (FARP). The fire alarm system and related smoke control systems will be functionally tested on an annual basis, to demonstrate proper operation as intended by the contract documents and the 1993 Amendments to the Denver Building Code (DBC). The smoke control system testing for Concourse C is broken down into two parts: Operating Tests and Performance Tests.

B. LOGISTICAL CONSIDERATIONS

1. Testing procedures described herein have been prepared for use by Impact Engineering, Inc. or DIA high-tech maintenance. Impact Engineering, Inc. or DIA high-tech maintenance will be responsible for performing their respective tests and for completing all entries on their respective data forms.
2. All testing operations and schedules must be coordinated with the appropriate general contractor.
3. The individuals who will perform the testing should be scheduled to be available full-time, without interruption, in order to maximize efficiency and to avoid missing any parts of the system.
4. The team testing each particular system should consist of at least two individuals, and possibly three. Where tests involve multiple systems (sprinkler flow and fire alarm), representatives from each trade shall be present.
5. One team member must remain in the Fire Department Operations Center (FDOC) at all times. This individual must be familiar with the operation of the fire alarm system and panels, emergency communications systems, and mechanical smoke control systems, as applicable. One or two additional team members will be required to test the devices and systems and observe alarm, emergency communication, and smoke control system performance, as applicable.
6. The team member in the FDOC must monitor the fire alarm system for any indications which are not related to the testing, and which could represent an actual alarm condition. All such alarms should be investigated immediately and the central station and/or fire department should be contacted, as appropriate.
7. The team must prepare all necessary data sheets and log books at the start of each testing exercise. Reduced scale as-built drawings and/or computer printouts may be used to record test results and performance data.
8. The results of the final approved tests, witnessed by either the Fire Prevention Bureau (FPB), or an independent testing agency approved by the FPB, shall be neatly recorded for turnover to the Owner.

9. Two-way radios should be utilized to provide a means of communication between the team member(s) in the test areas and the team member(s) in the FDOC.
10. Fire alarm systems and elevator recall, where applicable, should be tested separately. The fire alarm system interface that recalls elevators can then be overridden for the smoke control system testing.
11. Except for initial verification of correct operating conditions, testing of alarm initiating devices which automatically activate smoke control functions (fan and damper controls) shall have the interface for fan and damper control disabled (disconnected) during the smoke control system Operating Tests to avoid damage to equipment due to excessive and repeated fan start/stop and damper open/closed operation.
12. All systems must be complete and all previous deficiencies identified during the Operating Tests shall be corrected and verified prior to conducting the Performance Tests.

C. OPERATING TESTS

1. The following smoke control system tests shall apply to all buildings that contain smoke control systems, including those receiving construction permits prior to adoption of the 1993 Amendments to the DBC. The tests shall be conducted on an annual basis. Prior to conducting the Performance Tests defined hereinafter, the proper operation of smoke control system components shall be verified.
 - a. Verify proper status indication of smoke control dampers (i.e., "OPEN"/"CLOSED") and fans (i.e., "ON"/"OFF") by visual observation at each damper and fan location and at the CGP in the FDOC.
 - b. Verify that all smoke control dampers and fans assume the correct operating condition under both normal and fire modes and when the manual overrides are commanded from the CGP.
 - c. Verify that the manual override controls function properly for smoke control dampers and fans.
 - d. Items 1. a., b., and c. above can be performed by qualified service technicians who are familiar with the proper operation of the smoke control systems and equipment. Otherwise, the above testing either shall be performed by or directly supervised by a Professional Engineer licensed in the State of Colorado (Engineer). Direct supervision shall require the presence of the Engineer at the building, while the Operating Tests are taking place. If service technicians perform the Operating Tests, the Engineer responsible for either conducting or supervising the Performance Tests defined hereinafter, shall review the test procedures used and results obtained by the service technicians. A statement summarizing this review shall be included in the Test Report, that is required to be submitted by the Engineer to the FPB.
 - e. A copy of the written test procedure and an accurate log of tests shall be maintained in the FDOC. Any defects, system modifications and repairs shall be recorded in the log.

D. PERFORMANCE TESTS

2. Within 30 days of completing the annual Operating Tests defined hereinbefore, conduct tests to verify system performance as set forth in this Section. These tests shall apply to all buildings that contain smoke control systems, including those receiving construction permits prior to adoption of the 1993 Amendments to the DBC. These tests shall be conducted on an annual basis. The Performance Tests either shall be conducted by or shall be supervised directly by an Engineer. Direct supervision shall require the presence of the Engineer at the building, while the Performance Tests are taking place.
 - a. Activate the smoke control systems automatically through the fire alarm system for tests used to confirm proper sequencing of system components, actual relative pressure differentials between areas in alarm and adjacent areas, and actual door opening forces with the general building pressurization systems operating.
 - b. Conduct Performance Tests, observations and measurements of all aspects of the smoke control system at a minimum of five zones. Performance Tests in subsequent years shall be conducted on previously untested zones, as is practical so that all zones ultimately are tested.
 - c. At least one test shall include automatic activation of the smoke control system via a smoke detector, one test via a sprinkler flow alarm and one test via a manual pull station.
 - d. Measure pressure differentials or generate artificial smoke and observe smoke movement between locations or zones in alarm and adjacent locations or zones.
 - e. Upon activation of the fire alarm system for each test, confirm that the smoke control system fans and dampers have assumed the correct operating condition for the type of alarm initiating device and the location of initiating device. This shall be confirmed also at the smoke control CGP in the FDOC.
 - f. Manually override the operation of a sampling of fans during each test, taking care not to damage system component. Return all overrides to their "AUTO" control.
 - g. During at least one test, for buildings requiring elevator recall, confirm that the elevators return to the designated return floor and perform as required by the Code.

SECTION 2 - FORMS USAGE**A. OPERATING TESTS**

1. Fan System Overrides Data Form

- a. This form is intended to record all required visual verification of required equipment overrides and status indications as commanded from the CGP for the fan systems used for smoke control. Overrides identified are the HAND/OFF/AUTO positioning switch which is located at each respective fan system motor controller.
2. Damper Verification Requirements Data Form (Not Used)
 - a. This form is intended to record all required overrides and status indication as commanded from the CGP for dampers used for smoke control.
3. Duct Smoke Detector Verification Data Form
 - a. This form is intended to record all required duct smoke detector overrides and status, for fan systems required to shutdown based upon activation of their respective supply air or return air duct smoke detector.

B. PERFORMANCE TESTS

1. Fire Department Operations Center CGP Verification Data Form
 - a. This form is intended to record the performance of the smoke control system as indicated through the CGP located in the FDOC.
2. Zone Performance/Observation Data Form
 - a. This form is intended to record the actual smoke control systems performance by either measuring differential pressures or generating and observing artificial smoke movement. Door opening forces, where applicable, are also measured and recorded to confirm compliance with the DBC.

OPERATIONAL TEST REPORT

Project: Denver International Airport – Airport Office Building

Date: August 21, 2016

Author: Brian Zimmerman / Impact Engineering, Inc.

Distribution: Gerald Tyler/ DIA Life Safety

The following are a summary of outstanding items identified during our Operational Testing, which should be addressed prior to conducting Smoke Control Performance Testing on Concourse C:

DEDICATED PRESSURE AND EXHAUST FANS GRAPHICS AND CONTROL

1. AHU-4: The fan is not monitored properly. The fire alarm is monitoring the control module instead of actual fan status.
2. Graphics panel did not include SF-7 on the east side. This is inconsistent with what was provided on the west side and other fans that

END OF REPORT

PERFORMANCE TEST REPORT

Mr. Gerald Tyler
Denver International Airport
Life Safety Division
8500 Pena Boulevard
Denver, Colorado 80249-6340

Re: Denver International Airport – Airport Office Building
Smoke Control System Testing and Observation
Data Forms and Final Report and Certification for the 2016 Testing

Mr. Tyler:

Enclosed is a copy of our final smoke control systems testing and observation report for the Airport Office Building, which will accompany the “Smoke Control Systems Operational Testing database” and the stamped and signed “Smoke Control Systems Testing Procedures Manual / Data Forms” for the referenced projects. This final report concludes the 2013 annual testing as defined by our agreement.

In general, the smoke control systems for Airport Office Building performed in compliance with the construction documents as amended, with less than 1.0 % failure. This number is based both on the cumulative totals of component failures observed during the course of the Operational Testing. Since that time reportedly all deficiencies noted during the Operational Testing have been corrected and re-tested. The following is a summary of our testing observations, test methodology, qualifications, and concerns, and recommendations. Enclosed with this report is the summary of outstanding issues recorded and transmitted to you at various times during the “Operational” portion of this year’s smoke control systems testing.

**SUMMARY OF TESTING AND OBSERVATIONS
AIRPORT OFFICE BUILDING**

- A. Programming: It is recommended that the floor in exhaust be isolated. Currently all other exhaust dampers, other than the floor above and below, remain open. Smoke removal was marginal because the exhaust potential was diluted.

TEST METHODOLOGY

- A. Airport Office Building
1. All smoke control systems performance testing was conducted as prescribed by the approved Smoke Control System Testing Procedures Manual dated April 30, 1995.

RECOMMENDATIONS

A. Re-testing

1. Enclosed is a specific list of all deficiencies that were discovered during the operational or point-to-point testing of all the smoke control system components. All deficiencies have been corrected and re-tested prior to conducting the Performance Testing.
2. Attached in the Smoke Control Systems Testing Procedures / Data Forms for Airport Office Building is a specific list of all deficiencies that were discovered during the smoke control system performance testing relative to the fire alarm system graphic annunciation, zone performance, smoke containment and individual system component failure. At this time there are no deficiencies noted. No re-testing of the systems required.

QUALIFICATIONS

- A. It should be recognized that initial or annual performance tests, such as those conducted on the individual projects do not guarantee that the systems will perform in a similar manner under actual fire conditions. It is possible that component failure, due to normal wear and tear, vandalism or indeterminate causes, could occur immediately after the annual performance testing.

The data, conclusions and opinions presented in this report are based solely on the observations and information collected on the dates of the testing.

- B. Approved testing procedures are to confirm operation of the smoke control systems as installed for each contract. Confirmation for compliance with construction documents or the Denver Building Code for installation or control requirements is not apart of these services, unless non-conformance in this regard adversely affects smoke control system performance. Others during construction or as part of the initial occupancy testing should have performed confirmation of smoke control systems installations or control requirements.

The opportunity to continue to work with the DIA Life Safety Division on this assignment each year is appreciated. Further opportunity to assist in trouble-shooting any of the deficiencies and in fulfilling any of the recommendations as described herein would also be appreciated. Please advise if any questions or concerns.

Respectfully,
Impact Engineering, Inc.

Brian Zimmerman, PE

END OF REPORT

**DENVER INTERNATIONAL AIRPORT – AIRPORT OFFICE BUILDING
FAN SYSTEM OVERRIDES - OPERATING TESTS**System: **Fire Alarm**Service: **Airport Office Building**Performed by: **Impact Engineering, Inc.**

General Notes:

The following is a Data Base with a list of equipment intended to be utilized for the smoke control system. The Data Base is intended to be used by the Impact Engineering, Inc. in conjunction with the fire alarm system tenant design drawings, for visual verification of equipment overrides and status indication as required by the City and County of Denver Amendments to the IMC and NFPA Standards 92A and 92B.

Any deficiencies identified during the course of this testing are submitted as separate Outstanding Issues. All deficiencies identified shall be corrected and re-tested to verify proper operation in accordance with the system design, plans, specifications and the DBC.

A. FAN SYSTEM OVERRIDE TEST PROCEDURES

1. Clear/reset the fire alarm system of any previous alarms.
2. The team member(s) in the test areas should identify their position to the FDOC at each fan being tested.
3. Perform visual inspection of the fan configuration to confirm that all casing access doors are closed and that personnel are not in an unsafe location on or around the fan being tested.
4. Initiate fan overrides with the fan in the HAND, OFF and AUTO positions, where required at the respective motor starter.
5. Fan status during each of the identified overrides should be received at the FDOC.
6. Clear/reset fan status.
7. Record any deficiencies observed.

DENVER INTERNATIONAL AIRPORT – AIRPORT OFFICE BUILDING**FIRE DEPARTMENT OPERATIONS CENTER CGP VERIFICATION -
PERFORMANCE TESTS**System: **Fire Alarm**Service: **Airport Office Building**Performed by: **Impact Engineering, Inc.**

General Notes:

The following is a list of procedures for testing the smoke control system. The Data Forms are intended to be used by the Impact Engineering, Inc., in conjunction with the fire alarm system as-built drawings, for visual verification of equipment operation and status indication during various smoke control scenarios, as required by the City and County of Denver Amendments to the IMC and NFPA Standards 92A and 92B.

This form is intended to record the performance of the smoke control system as indicated through the CGP located in the FDOC.

Any deficiencies identified during the course of this testing shall be listed on the Data Forms. All deficiencies identified should be corrected and retested to verify proper operation in accordance with the system design, plans, specifications and the DBC.

A. SMOKE CONTROL TESTING AND OBSERVATION PROCEDURES

1. Assignments for individuals to be present in and to operate the FDOC. The test areas, and the fan rooms shall be determined and specific duties reviewed, on the day of the test when all representatives are present. Two-way radios shall be used for communication between test team members.
2. Confirm that artificial smoke generator and/or smoke bombs, air pressure gauges, and belt-tension gauges are available for use. Artificial smoke should be generated only in areas where air pressure measurements will not provide adequate verification of system performance.
3. Announce via the one-way communication system to the occupants of the building that life safety system tests will be conducted, and that they should disregard incidental activity of the fire alarm systems and of the air moving systems until further notice.
4. Enter all results and observed conditions on the Data Forms included. Data Form information ultimately will be compiled in the FDOC log book.
5. Take the fire alarm system off-line to the local fire station.

6. Disable the elevator recall function.
7. Confirm that all stairwell doors are closed.
8. Disable/silence the fire alarm system tone.
9. Record on the Data Forms the equipment used in the testing, outside air temperature and wind conditions at the beginning and at the end of the testing period.
10. Activation devices required to initiate the described sequences will be chosen on a zone-by-zone basis at the beginning of each test.
11. Clear/reset fire alarm system.
12. Record any deficiencies observed.

B. TEST INFORMATION - GENERAL

1. Smoke Control System Test Identification: No. ALL

Smoke Control System Test Date: 9/10/16

Testing Equipment: Rosco Smoke Generator
Belt Tension Gauge
Magnahelic Gauge 0.5 in H2o

	<u>Test Beginning</u>	<u>Test End</u>
Outside Air Temp	58 °F	59 °F
Wind Speed/Direction	2/SW	2/SW
Time (am/pm)	11:00 PM	1:00 AM

2. Witnessed By: Brian Zimmerman - IEI Date: 9/10/13

Jim Pena - DIA

Tyler Torres – DIA

C. DEFICIENCIES Refer to attached report.

DENVER INTERNATIONAL AIRPORT – AIRPORT OFFICE BUILDING**ZONE PERFORMANCE / OBSERVATION - PERFORMANCE TESTS**System: **Fire Alarm**Service: **Airport Office Building**Performed by: **Impact Engineering, Inc.**

General Notes:

The following is a list of procedures for testing the smoke control system. The Data Forms are intended to be used by the Impact Engineering, Inc., in conjunction with the fire alarm system as-built drawings, for visual verification of equipment operation and status indication during various smoke control scenarios, as required by the City and County of Denver Amendments to the IMC and NFPA Standards 92A and 92B.

This form is intended to record the actual smoke control systems performance by measuring differential pressures and generating artificial smoke. Door opening forces, where applicable, are also measured and recorded to confirm compliance with the Denver Building Code.

Any deficiencies identified during the course of this testing have been identified on the data forms included herein. All deficiencies identified will be corrected and retested to verify compliance prior to final acceptance by the Owner and jurisdictional authorities.

A. SMOKE CONTROL TESTING AND OBSERVATION PROCEDURES

1. Assignments for individuals to be present in and to operate the FDOC. The test areas shall be determined and specific duties reviewed, on the day or evening of the test when all representatives are present. Two-way radios shall be used for communication between test team members.
2. Confirm that artificial smoke generator and/or smoke bombs, air pressure gauges, and belt-tension gauges are available for use. Artificial smoke should be generated only in areas where air pressure measurements will not provide adequate verification of system performance.
3. Announce via the one-way communication system to the occupants of the building that life safety system tests will be conducted, and that they should disregard incidental activity of the fire alarm systems and of the air moving systems until further notice.
4. Enter all results and observed conditions on the Data Forms included. Data Form

information ultimately will be compiled in the FDOC log book.

5. Take the fire alarm system off-line to the local fire station.
6. Disable the elevator recall function.
7. Confirm that all stairwell doors are closed.
8. Disable/silence the fire alarm system tone.
9. Activation devices required to initiate the described sequences will be chosen on a zone-by-zone basis at the beginning of each test.
10. Clear/reset fire alarm system.
11. Record any deficiencies observed.

B. DEVICE ACTIVATION LOCATION – LEVEL 8

1. Smoke Control - Level Test Identification No.:01
 - a. Pressure Differentials:

Hoistway W3N47	<u>0.45</u> In. H ₂ O
Hoistway W3N48	<u>0.45</u> In. H ₂ O
Stairway W4N47	<u>0.25</u> In. H ₂ O
Stairway W6N47	<u>0.20</u> In. H ₂ O
Refuge Area W4N47	<u>0.35</u> In. H ₂ O
 - b. Smoke Containment (as required):

Hoistway W3N47	Containment	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
Hoistway W3N48	Containment	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
Stairway W4N47	Containment	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
Stairway W6N47	Containment	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
Refuge Area W4N47	Containment	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
 - c. Door Opening Forces:

Stairway W4N47	<u>25</u> #
Stairway W6N47	<u>22</u> #
Refuge Area W4N47	<u>20</u> #
 - d. Smoke Exhaust (as required):

Tenant Area

Exhaust Yes Noe. Witnessed By: Brian Zimmerman - IEIDate: 9 / 10 /13Jim Pena - DIATyler Torres – DIA**C. DEVICE ACTIVATION LOCATION – LEVEL 7**1. Smoke Control - Level

Test Identification No.:02

a. Pressure Differentials:

Hoistway W3N47	<u>0.43</u> In. H ₂ O
Hoistway W3N48	<u>0.43</u> In. H ₂ O
Stairway W4N47	<u>0.25</u> In. H ₂ O
Stairway W6N47	<u>0.21</u> In. H ₂ O
Refuge Area W4N47	<u>0.35</u> In. H ₂ O

b. Smoke Containment (as required):

Hoistway W3N47	Containment <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Hoistway W3N48	Containment <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Stairway W4N47	Containment <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Stairway W6N47	Containment <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Refuge Area W4N47	Containment <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No

c. Door Opening Forces:

Stairway W4N47	<u>20</u> #
Stairway W6N47	<u>21</u> #
Refuge Area W4N47	<u>22</u> #

d. Smoke Exhaust (as required):

Tenant Area

Exhaust Yes Noe. Witnessed By: Brian Zimmerman - IEIDate: 9 / 10 /16Tom Tyler - DIATyler Torres – DIA**D. DEVICE ACTIVATION LOCATION - REFUGE AREA LEVEL 8**

1. Smoke Control - Level Test Identification No.:03
- a. Pressure Differentials:
- | | | |
|-------------------|------|----------------------|
| Hoistway W3N48 | 0.40 | In. H ₂ O |
| Hoistway W3N47 | 0.45 | In. H ₂ O |
| Refuge Area W4N47 | 0.40 | In. H ₂ O |
- b. Smoke Containment (as required):
- | | | | |
|-------------------|-------------|---|-----------------------------|
| Hoistway W3N48 | Containment | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Hoistway W3N47 | Containment | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Refuge Area W4N47 | Containment | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
- c. Witnessed By: Brian Zimmerman - IEI Date: 9 / 10 /16
Jim Pena - DIA
Tyler Torres – DIA

E. DEVICE ACTIVATION LOCATION - REFUGE AREA LEVEL 7

1. Smoke Control - Level Test Identification No.:04
- a. Pressure Differentials:
- | | | |
|-------------------|------|----------------------|
| Hoistway W3N48 | 0.50 | In. H ₂ O |
| Hoistway W3N47 | 0.50 | In. H ₂ O |
| Refuge Area W4N47 | 0.50 | In. H ₂ O |
- b. Smoke Containment (as required):
- | | | | |
|-------------------|-------------|---|-----------------------------|
| Hoistway W3N48 | Containment | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Hoistway W3N47 | Containment | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Refuge Area W4N47 | Containment | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
- c. Witnessed By: Brian Zimmerman - IEI Date: 9 / 10 /16
Tom Tyler - DIA
Tyler Torres – DIA

F. DEFFICIENCIES Refer to attached report.