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NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

TechNotes

Editor - Mark Hopkins, P.E Issue # 393 April 10, 2018

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The following issue of TechNotes has been written by Robert (Bob) Upson, Manager of Engineering Services for the NFSA.

Best of March 2018

Following are a dozen questions answered by the engineering staff as part of the NFSA's Expert of the Day (EOD) member assistance program during the month of March 2018. This information is being brought forward as the "Best of March 2018." If you have a question for the NFSA EOD (and you are an NFSA member), send your question to eod@nfsa.org and the EOD will get back to you.

It should be noted that the following are the opinions of the NFSA Engineering Department staff, generated as members of the relevant NFPA technical committees and through our general experience in writing and interpreting codes and standards. They have not been processed as formal interpretations in accordance with the NFPA Regulations Governing Committee Projects and should therefore not be considered, nor relied upon, as the official positions of the NFPA or its Committees. Unless otherwise noted the most recent published edition of the standard referenced was used.

Question 1 - Seismic Design Category Determination

How is the Seismic Design Category, which affects seismic protection requirements for fire sprinkler systems in accordance with NFPA 13, determined for a building?

Answer: NFPA 13 itself contains no requirements as to where seismic protection features are required. It is generally the adopted building code that does so and NFPA 13 then provides information on how to provide such protection.

The concept of seismic design categories was first published in what was known as the National Earthquake Hazard Reduction Program (NEHRP) developed by the Building Seismic Safety Council (BSSC) with federal funding. The procedures are now located within ASCE-7 and are

Upcoming Technical Tuesdays

April 17, 2018

An Overview of Corrosion in Sprinkler Systems
by Mark Hopkins, P.E.
V.P. of Engineering

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referenced by the International Building Code (IBC) which is used as the basis of most building codes throughout the country. These codes do not require fire sprinkler systems to be protected against earthquakes in the low-hazard Seismic Design Category A and B buildings. Other types of mechanical systems are also exempted from the need for seismic protection in Seismic Design Category C, but not fire sprinkler systems due to their higher importance factor.

Because project design professionals need to determine the Seismic Design Category for a variety of needs beyond fire sprinkler systems, it is a determination that is not generally made by fire sprinkler system designers or installers, since it requires knowledge of prevailing soil conditions for the project as well as mapped potential ground accelerations. On a new project, the identification of the Seismic Design Category should be part of the available project specifications.

If the Seismic Design Category is C, D, E, or F, building codes generally require that the sprinkler system be provided with seismic protection. Proper application of the NFPA 13 protection criteria also then requires the use of a "seismic coefficient" CP to develop horizontal force values per Table 9.3.5.9.3 (2016 edition). As can be seen in the table, these values are based on the "short-period" accelerations, SS, that are found in the maps prepared by the U.S Geological Survey. The SS value should also be available from project design professionals, since it is used during the determination of the Seismic Design Category.

Question 2 - Required Standpipe Flow at Most Remote Hose Connections.

NFPA 14 (2016) section 7.10.1.2 regarding the flow requirements for standpipes has been changed.

> ***7.10.1.2* Hydraulic Calculation Requirements.***
>
> ***7.10.1.2.1*** *Hydraulic calculations and pipe sizes for each standpipe shall be based on providing 250 gpm (946 L/min) at the two hydraulically most remote hose connections on the standpipe and at the topmost outlet of each of the other standpipes at the minimum residual pressure required by Section 7.8.*

Is the intent of this section to flow 250 gpm from the topmost hose connection and an additional 250 gpm from the hose connection at the floor below?

Answer: The answer to your question is "Yes." The intent has always been to flow 250 gpm each from the uppermost two hose outlets on the most hydraulically remote standpipe. Typically, these two outlets would be the topmost hose connection and the hose connection at the floor below. However, this requirement has frequently been misinterpreted to require 500 gpm from the topmost hose connection(s) all from the top floor level. This language has

been changed several times in recent additions and may see some additional changes in the 2019 edition.

Language from the 2010 edition.

> ***7.10.1.2.1*** *Hydraulic calculations and pipe sizes for each standpipe shall be based on providing 250 gpm (946 L/min) at the two hydraulically most remote hose connections on the standpipe and at the topmost outlet of each of the other standpipes at the minimum residual pressure required by Section 7.8.*

Language from the 2013 edition.

> ***7.10.1.1.1*** *For Class I and Class III systems, the minimum flow rate for the hydraulically most remote standpipe shall be 500 gpm (1893 L/min), through the two most remote 2 1/2 in. (65 mm) outlets, and the calculation procedure shall be in accordance with 7.10.1.2.*

2019 edition First Draft language with editorial changes.

> ***7.10.1.2.1*** *Hydraulic calculations and pipe sizes for each standpipe shall be based on providing 250 gpm (946 L/min) at the two hydraulically most remote hose connections on the standpipe and at the topmost outletconnection point of each of the other standpipes at the minimum residual pressure required by Section 7.8.*

Question 3 - Cloud Ceiling Reference in NFPA 13 (2016) 8.15.24.1(1)

NFPA 13 (2016) section 8.15.24.1 regarding cloud ceiling rules references section 8.15.1.2.1.2.

> ***8.15.24.1**** *Sprinklers shall be permitted to be omitted above cloud ceilings where both of the following apply:*
> *(1)*The openings around the cloud and the maximum sprinkler protection area meet the requirements of 8.15.1.2.1.2 and Table 8.15.24.1*
> *(2) The requirements of 8.15.24.2 are met.*
>
> ***8.15.1.2.1.2*** *Small openings with a combined total area of not more than 20 percent of the ceiling, construction feature, or plane used to determine the boundaries of the concealed space shall be permitted where length greater than 4 ft (1.2 m) shall not have a width greater than 8 in. (200 mm).*

Is the correct reference section 8.15.1.2.1.3 which does not limit the width of openings greater than 4 feet in length?

> ***8.15.1.2.1.3*** *The space above cloud ceilings meeting the requirements in 8.15.24.1 and having openings with a combined total area of not more than 20 percent of the ceiling, construction feature, or plane used to determine the boundaries of the concealed space shall be permitted.*

Answer: The answer to your question is "Yes," although NFPA does not appear to have issued an erratum on this issue. Section 8.15.1.2.1.3 is consistent with the research conducted in the development of the cloud ceiling rules and the corresponding proposed language in 9.2.7.1 in the forthcoming 2019 edition (as of the Second Draft) is consistent with 8.15.1.2.1.3 rather than 8.15.1.2.1.2.

> ***9.2.7.1**** *Sprinklers shall be permitted to be omitted above cloud ceilings where all of the following apply:*
> *(1)*The combined total area of the openings around the cloud are less than or equal to 20 percent of the area of the ceiling, construction feature, or plane used to determine the boundaries of the compartment.*
> ....

Question 4 - Existing Ordinary Hazard System in Residential Conversion

A heavy timber warehouse is being converted into dwelling units. The existing sprinkler system is an ordinary hazard pipe schedule system with standard spray upright sprinklers. The sprinklers are only 20 years old but the AHJ is requiring them to be replaced with quick response sprinklers. There is a concern that a residential sprinkler might be required but also a question about the availability of residential upright sprinklers.

Is it the intention of NFPA 13 to require the existing standard response sprinklers to be replaced with quick response sprinklers in this situation?

Answer: The answer to your question is "No." The existing ordinary hazard system is already designed to provide a higher degree of protection than the light hazard protection typically associated with residential occupancies. If the sprinklers are changed for new sprinklers with the same k-factor to retain the ordinary hazard protection, NFPA 13 (2016) section 8.4.1.1 permits either standard spray or quick response uprights. There is no requirement in the standard for them to be quick response except in new light hazard systems as per section 8.3.3.1. As this building is being protected as an ordinary hazard with an ordinary hazard system, section 8.3.3.1 does not apply.

> ***8.4.1.1*** *Upright and pendent spray sprinklers shall be permitted in all occupancy hazard classifications and building construction types unless the requirements of 8.15.1.6 apply.*

> ***8.3.3.1**** *Sprinklers in light hazard occupancies shall be one of the following:*
> *(1) Quick-response type as defined in 3.6.4.8*
> *(2) Residential sprinklers in accordance with the requirements of 8.4.5*
> *(3) Quick response CMSA sprinklers*
> *(4) ESFR sprinklers*

(5) Standard-response sprinklers used for modifications or additions to existing light hazard systems equipped with standard-response sprinklers
(6) Standard-response sprinklers used where individual standard-response sprinklers are replaced in existing light hazard systems

Residential sprinklers are permitted as per section 8.4.5.1 but they are not required for residential applications in NFPA 13. (We are aware of at least two manufacturers offering upright residential sprinklers if that option is desired but switching to residential would create additional complications.)

8.4.5.1* *Residential sprinklers shall be permitted in dwelling units and their adjoining corridors, provided they are installed in conformance with their listing.*

If the existing system was a light hazard pipe schedule system, a case could be made for replacing standard response sprinklers with quick response. Note that reducing the k-factor to approximate a light hazard system or changing the design criteria (area/density to residential) would likely be grounds to trigger a requirement for hydraulic calculation of the entire system rather than just revamping the existing approved pipe schedule system as it stands.

Question 5 - Foam Generators in a Group II Hangar

NFPA 409 (2016) section 7.1.6 regards the installation of high expansion foam in a Group II hangar. NFPA 11 (2016) section 6.12.8.2.3 and its subsections provide calculations for the rate of foam discharge. NFPA 409 (2016) section 7.5.3 specifically calls out section 6.12.8.2.3.2 regarding the factor (RS) as compensation for foam breakdown caused by sprinklers.

7.1.6 *Each foam protection system shall be designed, installed, and maintained in accordance with NFPA 11.*

6.12.8.2.3 Calculation.
6.12.8.2.3.1* *The minimum rate of discharge or total generator capacity shall be calculated from the following formula:*

where:
R = rate of discharge in m3/min (ft3/min)
V = submergence volume in m3 (ft3)
T = submergence time in minutes
RS = rate of foam breakdown by sprinklers in m3/min (ft3/min)
CN = compensation for normal foam shrinkage
CL = compensation for leakage

6.12.8.2.3.2* *The factor (RS) for compensation for breakdown by sprinkler discharge shall be determined either by test or, in the absence of specific test data, by the following formula:*

where:

S = foam breakdown in m3/min· L/min (ft3/min · gpm) of sprinkler discharge. S shall be 0.0748 m3/min· L/min (10 ft3/min · gpm)
Q = estimated total discharge from maximum number of sprinklers expected to operate in L/min (gpm)

6.12.8.2.3.3 *The factor (CN) for compensation for normal foam shrinkage shall be 1.15, which is an empirical factor based on average reduction in foam quantity from solution drainage, fire, wetting of surfaces, absorbency of stock, and so forth.*

6.12.8.2.3.4* *The factor (CL) for compensation for loss of foam due to leakage around doors and windows and through unclosable openings shall be determined by the design engineer after evaluation of the structure. This factor shall not be permitted to be less than 1.0 even for a structure completely tight below the design filling depth. This factor shall be permitted to be as high as 1.2 for a building with all openings normally closed, depending on foam expansion ratio, sprinkler operation, and foam depth.*

7.5 High-Expansion Foam System.
....
7.5.3 *The discharge rate of the system shall be based on the application rate multiplied by the entire aircraft storage and servicing floor area. The application total discharge rate shall include the sprinkler breakdown factor specified in 6.12.8.2.3.2 of NFPA 11.*
....

Given that they are not called out by NFPA 409 (2016) section 7.5, are the compensation factors, CN and CL, in NFPA 11 (2016) sections 6.12.8.2.3.3 and 6.12.8.3.4 required by NFPA 409?

Answer: The answer to your question is "Yes." The base formula in section 6.12.8.2.3.1 calls for these compensation factors so they must be used. The formula stated in NFPA 11 can be applied to both systems with and without sprinklers as suggested in section A.6.12.8.2.3.2.
NFPA 409(2016) section 7.5.3 emphasizes that the breakdown of foam by concurrent sprinkler activation must be accounted for in this application.

A.6.12.8.2.3.2 *Where sprinklers are present in an area to be protected by high-expansion foam, simultaneous operation will cause breakdown of the foam. The rate of breakdown will depend on the number of sprinklers operating and the subsequent total rate of water discharge. The number of sprinklers expected to operate will depend on various factors as outlined in NFPA 13.*

Question 6 - Pendent Sprinklers Placed Between Cloud Ceiling Panels

Are pendent sprinklers permitted to be placed in the open areas between panels in a cloud ceiling?

Answer: It is neither specifically permitted nor specifically prohibited by the standard but could be acceptable under certain conditions if the AHJ agrees. Assuming that all the requirements of section 8.15.24 for cloud ceilings are met, it could be argued that sprinklers could be placed in the center of the open space between cloud ceiling panels provided that the separation between panels does not exceed 6 inches and the deflector is below the level of the cloud panels. This argument is based on the rules for installing sprinklers to provide protection under an obstruction, particularly section 8.5.5.3.1.1, which permits sprinklers to be placed within 3 inches adjacent to the obstruction it is protecting. It would be up to the AHJ's interpretation to accept or reject this arrangement. The more typical arrangement is to place the sprinklers in the cloud panels spaced according to the requirements of section 8.15.24.

> ***8.5.5.3* Obstructions that Prevent Sprinkler Discharge from Reaching Hazard.*** *Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (450 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with 8.5.5.3.*
>
> ***8.5.5.3.1**** *Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) in width.*
>
> ***8.5.5.3.1.1*** *Sprinklers shall be located below the obstruction and not more than 3 in. (75 mm) from the outside edge of the obstruction.*
>
> ***8.5.5.3.1.2*** *Where sprinklers are located adjacent to the obstruction, they shall be of the intermediate level rack type.*
>
> ***8.5.5.3.1.3*** *The deflector of automatic sprinklers installed under fixed obstructions shall be positioned no more than 12 in. (300 mm) below the bottom of the obstruction.*
>
> ***8.5.5.3.1.4*** *Sprinklers shall not be required under noncombustible obstructions over 4 ft (1.2 m) wide where the bottom of the obstruction is 24 in. (600 mm) or less above the floor or deck.*

Question 7 - Backflow Preventer - Rated Flow

Backflow assembly manufacturers publish friction loss curves that typically include a 'rated flow' point.

Is it acceptable to use a backflow assembly for a fire protection system demand higher than the 'rated flow'?

Answer: The answer to your question is "Yes." The rated flow is for day-to-day normal operation. As a rule of thumb, if the manufacturer has provided friction loss data for a

particular demand flow, that backflow assembly is of adequate size for that fire protection application. The 'rated flow' is more important in applications where the backflow serves both domestic flows and emergency fire flows. In that case, the typical domestic flow should not exceed the 'rated flow'. The issue is potential wear due to day-to-day high flow velocity in a backflow preventer that has been undersized for its application. An infrequent rise in flow velocity due to the activation or full forward flow testing of a fire protection system does not create this problem.

Question 8 - NFPA 13 2010, IBC 2012, IFC 2003 & ASME A17.1

An 8-story casino of noncombustible construction has 3 elevators. A 1-inch valve with a tamper switch has been installed for the isolation of the piping for each elevator pit sprinkler. The drawing was approved by the AHJ but now the same AHJ is stating that a self-closing valve is required as part of the shunt trip system which is a mandatory requirement of the IBC. Heat detection will be used for shunt trip in accordance with IBC (2012) section 907.3.1.

Is there a requirement for self-closing valves in the IBC?

Answer: The answer to your question is "No." IBC (2012) section 3006.5 identifies that, where sprinklers are provided within elevator hoistways and machine rooms, a means to disconnect power in accordance with NFPA 72 shall be provided. The specification section that was provided indicates that heat detectors will be used for this purpose. NFPA 72 requires a heat detector to be located within 2 ft of every sprinkler for this purpose.

> ***3006.5 Shunt trip.*** *Where elevator hoistways or elevator machine rooms containing elevator control equipment are protected with automatic sprinklers, a means installed in accordance with NFPA 72, Section 6.16.4, Elevator Shut down, shall be provided to disconnect automatically the main line power supply to the affected elevator prior to the application of water. This means shall not be self-resetting. The activation of sprinklers outside the hoistway or machine room shall not disconnect the main line power supply.*

Commentary language for this section clarifies that the intention is to prevent hazards associated with sprinklers and primarily electrical malfunction.

- *This section acknowledges the hazards of a sprinkler system, mainly electrical malfunction, to an operating elevator and elevator equipment contained in the machine room. Therefore, the main power supply line to the affected elevator(s) is required to automatically disconnect, and not be reset, before the suppression system is activated.*

The heat detectors will respond prior to the sprinklers due to the lower RTIs and activation temperatures associated with these detectors. This fulfills the shunt trip requirement since the heat detector will initiate operation of a shunt trip breaker. The configuration depends on the elevator equipment and the fire alarm system equipment so specific details cannot be provided. However, there is no requirement to stop waterflow.

Valves are required to be supervised in accordance with IBC (2012) section 903.4. There is no requirement for isolation valves for elevator pit sprinklers to be self-closing.

Question 9 - Comparing Main Drain Tests to Hydraulic Placards

Are main drain test results required to be compared to hydraulic placard design criteria? Do residual pressure results need to be checked against the system demand pressure at the base of the riser?

Answer: The answer to your question is "No." NFPA 25 (2017) does not require comparison of the main drain test results to the design criteria identified on the hydraulic placard. The applicable NFPA 25 requirements are as follows.

> ***13.2.5* Main Drain Test.*** *A main drain test shall be conducted annually for each water supply lead-in to a building water-based fire protection system to determine whether there has been a change in the condition of the water supply.*
>
> ***A.13.2.5*** *Main drains are installed on system risers for one principal reason: to drain water from the overhead piping after the system is shut off. This allows the contractor or plant maintenance department to perform work on the system or to replace nozzles after a fire or other incident involving system operation.*
> *...*
> ***13.2.5.3*** *When there is a 10 percent reduction in full flow pressure when compared to the original acceptance test or previously performed tests, the cause of the reduction shall be identified and corrected if necessary.*

The reference to "change in the condition of the water supply" in section 13.2.5 does not mean comparison to the design criteria identified on the hydraulic placard. Section 13.2.5.3 requires comparison to the results of the original acceptance test or previously performed tests. If there is a 10 percent reduction in the full flow pressure an investigation and correction would be required, if determined to be necessary. For example, if a residual pressure of 55 psi was previously recorded while the drain valve was in the fully open position and a pressure of 49 psi was observed during the main drain test with the valve fully open then there would be cause for investigation since there is a reduction in full flow pressure greater than 10 percent.

The flow identified on the hydraulic placard will likely not be able to be achieved through the main drain since NFPA 13 does not require the main drain to be sized to accommodate the full sprinkler system demand flow. Clarification regarding the purpose of the main drain has provided in section A.13.2.5 by the NFPA 25 Technical Committee. It is provided to drain water from the system.

Question 10 - NFPA 22 Calculating Water Tank Size

10-1) When sizing a water tank for fire protection, is it necessary to include the hose allowance when multiplying the system demand and the required demand duration?

Answer 10-1: The answer to your question is "Yes, but only if the tank is expected to supply hose streams." NFPA 22 (2013) section 4.1.4 requires the tank to be sized to meet the demand it is expected to support during the design duration. Unless the fire protection system(s) supplied by the tank includes private fire hydrants or inside hose stations for firefighting purposes, the tank does not need to support a hose allowance. This is further clarified in NFPA 13 (2016) section 11.1.5.2 and its annex commentary.

> ***4.1.1**** *The size and elevation of the tank shall be determined by conditions at each individual property after due consideration of all factors involved.*
>
> ***A.4.1.1*** *Where tanks are to supply sprinklers, see separately published NFPA standards; also see NFPA 13.*
>
> ***4.1.4*** *A tank shall be sized so that the stored supply plus reliable automatic refill shall be sufficient to meet the demand placed upon it for the design duration.*
>
> ***11.1.5 Water Supplies.***
>
> ***11.1.5.1*** *The minimum water supply shall be available for the minimum duration specified in Chapter 11.*
>
> ***11.1.5.2**** *Tanks shall be sized to supply the equipment that they serve.*
>
> ***A.11.1.5.2*** *Where tanks serve sprinklers only, they can be sized to provide the duration required for the sprinkler system, ignoring any hose stream demands.Where tanks serve some combination of sprinklers, inside hose stations, outside hose stations, or domestic/process use, the tank needs to be capable of providing the duration for the equipment that is fed from the tank, but the demands of equipment not connected to the tank can be ignored. Where a tank is used for both domestic/process water and fire protection, the entire duration demand of the domestic/process water does not need to be included in the tank if provisions are made to segregate the tank so that adequate fire protection water is always present or if provisions are made to automatically cut off the simultaneous use in the event of fire.*

10-2) Based on NFPA 13 (2016) section 11.2.3.1.1(1) is it permissible to calculate the system demand for purposes of tank sizing based solely on the required design density multiplied by the required design area?

> ***11.2.3.1.1*** *The water demand for sprinklers shall be determined only from one of the following, at the discretion of the designer:*
> *(1) Density/area curves of Figure 11.2.3.1.1 in accordance with the density/area method of 11.2.3.2*
> *....*

Answer 10-2: The answer to your question is "Yes, (by a strict but probably not intended reading) but this creates an effective conflict with Chapter 24 Water Supplies. The actual calculated demand flow should be used as simply multiplying the minimum design density and design area will under-predict the actual demand flow required by the system. Section 11.2.3.1.1 provides options for determining the minimum flow permissible from each sprinkler in the system based on the occupancy hazard classification. Option (1) can be used to approximate the actual design flow required by adding 15 to 30% for 'overage' depending on the system type and configuration. Section 24.1.2 requires that the water supply is capable of supplying the remote design area demand flow which can only be assured by using the calculated flow and pressure.

> ***24.1.2 Capacity.*** *Water supplies shall be capable of providing the required flow and pressure for the remote design area determined using the requirements and procedures as specified in Chapters 11 through 22 including hose stream allowance where applicable for the required duration.*

Question 11 - ESFR and Baffles

A demising wall has been removed in a building having an ESFR sprinkler system. The removal of the wall resulted in ESFR sprinklers being too far from the wall (7 feet, 6 inches). NFPA 13 only references the use of draft curtains (baffles) for separation of ESFR sprinkler systems adjacent to systems with standard response sprinklers. The existing ESFR sprinklers are too close to the demising wall to add an additional line of sprinklers.

Would it be permissible to install a baffle between these ESFR's even though they are closer than the minimum spacing of 8 feet?

Answer: The answer to your question is "No." Baffles are not permitted for use with ESFR sprinklers. Draft curtains are used for the specific condition involving an adjacent ESFR sprinkler system to a system with standard response sprinklers. The use of draft curtains/baffles as described would not be appropriate. ESFR sprinklers installed closer than 8 feet, even with baffles, is not permitted due to the possibility of sprinkler skipping. Relocation of the existing

sprinklers near the wall would not be permitted since the only shift allowance would be for those impacted by structural members as permitted by section 8.12.3.1(4). A possible configuration would be to add a row ESFR sprinklers near the wall. The sprinkler should be installed no closer than 4 inches as required by NFPA 13 (2016) section 8.12.3.3. Rather than using the described baffle, new sprinklers should be offset from the existing sprinklers such that they are no closer than 8 feet from the existing sprinklers. This might require new sprinklers to be staggered such that are centered between two existing sprinklers. If the sprinklers are located 4 inches from the wall, they would need to be offset by approximately 3 feet, 7 inches (x2 = 82 - 7.1372, x = 3.55 feet) from the nearest sprinkler.

Question 12 - VTAC Closets

A 7-story noncombustible residential building contains noncombustible 'closets' with service vents, service panels, and no doors. These 'closets' house electric vertical terminal air conditioner (VTAC) units. Each 'closet' measures approximately 2 feet 6 inches by 2 feet 6 inches in area. The governing codes and standards are NFPA 101 (2012) and NFPA 13 (2010).

Do these 'closets' require sprinklers?

Answer: The answer to your question is "No." These spaces are properly considered noncombustible concealed spaces as per section 8.15.1.2.2 and sprinklers may be omitted.

> ***8.15.1.2.2*** *Concealed spaces of noncombustible and limitedcombustible construction with limited access and not permitting occupancy or storage of combustibles shall not require sprinkler protection.*
>
> ***8.15.1.2.2.1*** *The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.*