HIGH EXPANSION FOAM AND SUPPRESSION SYSTEMS FOR DOD HANGARS

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BY BRIAN ERBSTOESSER, PE

FOR GREAT PLAINS CHAPTER SFPE

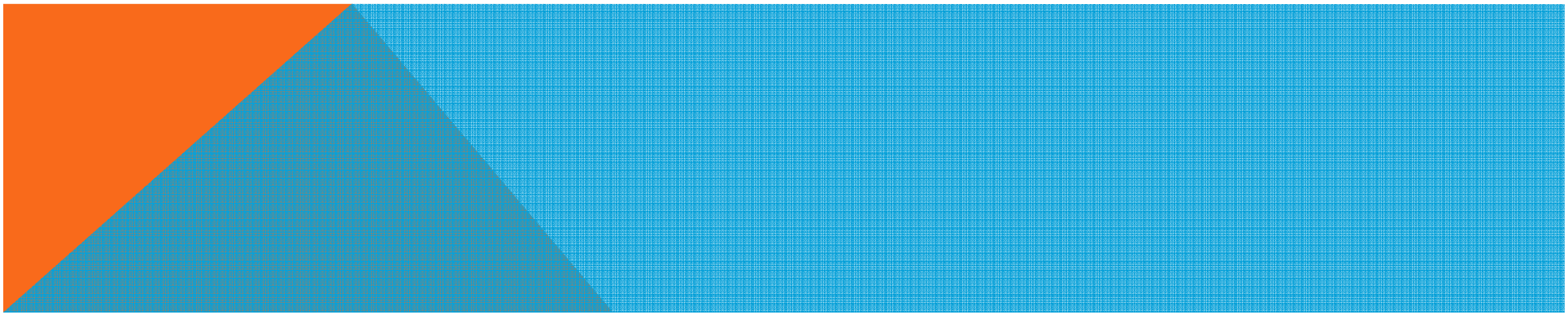
Introduction – DoD Hangars are used for shelter, maintenance, and inspections of aircraft and helicopters that are worth millions of dollars. Fire suppression systems are there to protect the aircraft and helicopters, buildings, and above all… personnel. This presentation is to discuss DoD Fire Suppression Systems for Hangars.

Presentor – Brian Erbstoesser, PE – Fire Protection Engineer, 17 Years of Experience

What are typical systems that protect Department of Defense Hangars?

Wet Pipe Sprinkler Systems – Administration Areas
Dry Pipe Sprinkler Systems – Hangar Bays
Low Level, High Expansion Foam – Hangar Bays

What is Low Level, High Expansion Foam?



Starting Point – Criteria

Private Sector uses National Fire Protection Association (NFPA) 409

Department of Defense (DoD) uses Various Criteria (Army, Navy, Airforce, Marines)

- Unified Facilities Criteria (UFCs)
  - 3-600-01
  - 4-211-01, 4-211-01N
  - 4-211-02, 4-211-03F
- Engineering Technical Letter (ETLs)
  - AF ETL 02-15
- Engineering Construction Bulletins (ECBs)
  - ECB 2015-17
- NFPA
  - NFPA 11, 11A, 20, 22, 24, 70, 72, 409

Where to find the criteria? www.wbdg.org (Whole Building Design Guide)

NOTE: Many changes in the criteria over the last 4 years – can be confusing

Have criteria…now what?

How to protect hangars?

Active Systems:

- Wet Pipe Sprinkler Systems in Administration Areas – Typical for All Normal Buildings (Light Hazard, Ordinary Hazard, etc.)
- Dry Pipe Sprinkler System for Hangar Bays (Requirement is .2 gpm over 5,000 square feet).
- Low Level, High Expansion Foam System in Hangar Bay as well as the Dry Pipe System.

Passive Components:

- Draft Curtains every 15,000 square feet.
- Hangar Separated by All Other Areas by Minimum 1 Hour Fire Rated Walls

Let's Talk Low Level, High Expansion Foam System....

Typical Components:

High Expansion Foam – 2% or 3% - Not AFFF

Typical Components - Continued

Atmospheric Storage Tank – No Bladder Tanks

High Expansion Foam Generator

Foam Proportioner In-line

Typical Components - Continued

Foam Pumps – Stainless Steel or Resistant to Foam Corrosion

Deluge Valve - Electric

Multi-Spectrum IR Flame Detector

Design Strategy – How to Design the System?

NFPA 11 (National Fire Protection Association) is General Guidance

It is the basis for ETL 02-15

What is required? Performance….

Cover 90 Percent of Aircraft Silhouette in one minute or less (floor layout)

Cover aircraft servicing area and adjacent areas to a depth of one meter (3.2 feet) In four minutes or less

2.6 cubic feet min/square feet to 4 cubic feet min/square feet

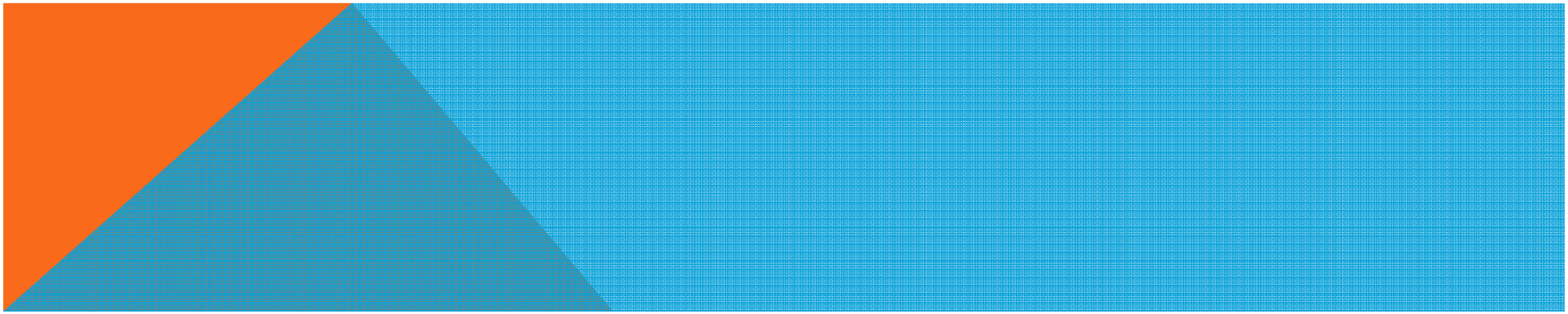
Important Necessary Data:

NFPA 291 – Hydrant Flow Test Data – Available Water Flow and Pressure (critical design information)

This determines need for Fire Pumps, Foam Concentrate Pumps, Foam Generators, and overall System Performance

Select some preliminary equipment (HEF Generators) and put together some possible layouts

Start calculations…..What calculations?



Calculate Minimum Discharge Rate or Total Generator Capacity

$R=(\{V/T\}+Rs) \times Cn \times Cl$

R=Rate of discharge in cubic feet/min
V=Submergence volume in cubic feet (next formula)

$V=A \times D$
A= Area of the aircraft servicing floor and adjacent floor areas (square feet)
D=Depth = 3.28 feet

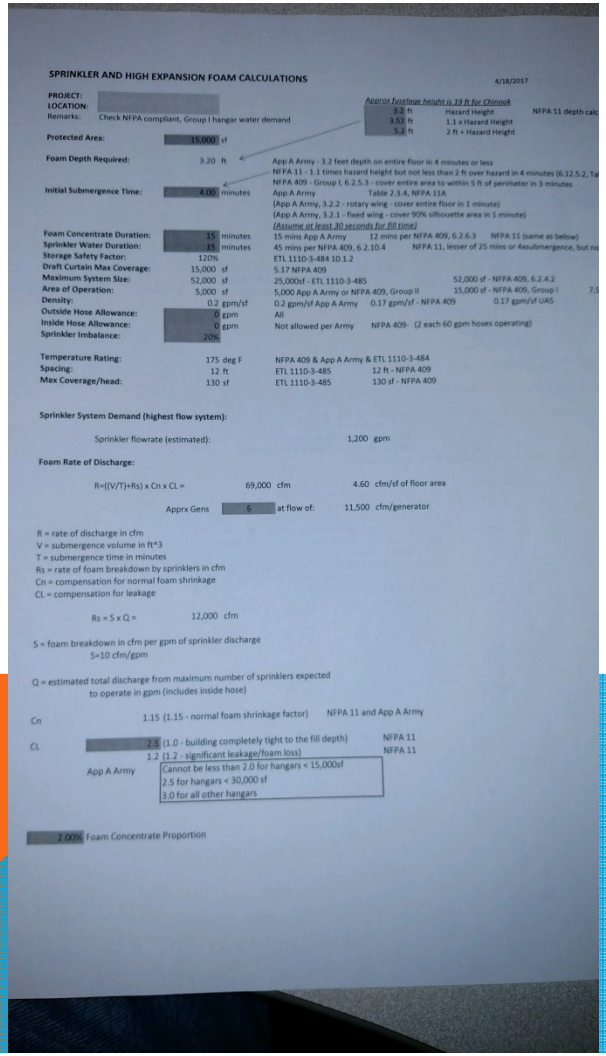
T= Submergence time in minutes = 4 minutes
Rs= Rate of foam breakdown by sprinklers (next formula)

$Rs = S \times Q$
S=Foam breakdown from sprinklers (10 cubic feet per minute * gpm)
Q= Estimated total discharge from sprinklers (expected to operate)

Cn = Compensation for normal foam shrinkage = 1.15 (empirical)
Cl = Compensation due to leakage around doors and windows and unclosable openings (values in ETL 02-15)

The calculations can be done by hand.

A good tool is an Excel Spreadsheet created by US Army Corps of Engineers Mobile District



SPRINKLER AND HIGH EXPANSION FOAM CALCULATIONS

4/18/2017

PROJECT:
LOCATION:
Remarks: Check NFPA compliant, Group I hangar water demand

Approx fuselage height is 19 ft for Chinook
3.2 ft Hazard Height
3.52 ft 1.1 x Hazard Height
5.2 ft 2 ft + Hazard Height
NFPA 11 depth calc

Protected Area:	15,000	sf	
Foam Depth Required:	3.20	ft	App A Army - 3.2 feet depth on entire floor in 4 minutes or less NFPA 11 - 1.1 times hazard height but not less than 2 ft over hazard in 4 minutes (6.12.5.2, Ta
Initial Submergence Time:	4.00	minutes	NFPA 409 - Group I, 6.2.5.3 - cover entire area to within 5 ft of perimeter in 3 minutes App A Army Table 2.3.4, NFPA 11A (App A Army, 3.2.2 - rotary wing - cover entire floor in 1 minute) (App A Army, 3.2.1 - fixed wing - cover 90% silhouette area in 1 minute) *(Assume at least 30 seconds for fill time)*
Foam Concentrate Duration:	15	minutes	15 mins App A Army 12 mins per NFPA 409, 6.2.6.3 NFPA 11 (same as below)
Sprinkler Water Duration:	15	minutes	45 mins per NFPA 409, 6.2.10.4 NFPA 11, lesser of 25 mins or 4xsubmergence, but no
Storage Safety Factor:	120%		ETL 1110-3-484 10.1.2
Draft Curtain Max Coverage:	15,000	sf	5.17 NFPA 409
Maximum System Size:	52,000	sf	25,000sf - ETL 1110-3-485 52,000 sf - NFPA 409, 6.2.4.2
Area of Operation:	5,000	sf	5,000 App A Army or NFPA 409, Group II 15,000 sf - NFPA 409, Group I
Density:	0.2	gpm/sf	0.2 gpm/sf App A Army 0.17 gpm/sf - NFPA 409 0.17 gpm/sf UAS
Outside Hose Allowance:	0	gpm	All
Inside Hose Allowance:	0	gpm	Not allowed per Army NFPA 409- (2 each 60 gpm hoses operating)
Sprinkler Imbalance:	20%		
Temperature Rating:	175	deg F	NFPA 409 & App A Army & ETL 1110-3-484
Spacing:	12	ft	ETL 1110-3-485 12 ft - NFPA 409
Max Coverage/head:	130	sf	ETL 1110-3-485 130 sf - NFPA 409

Sprinkler System Demand (highest flow system):

Sprinkler flowrate (estimated): 1,200 gpm

Foam Rate of Discharge:

R=((V/T)+Rs) x Cn x CL = 69,000 cfm 4.60 cfm/sf of floor area

Apprx Gens 6 at flow of: 11,500 cfm/generator

R = rate of discharge in cfm
V = submergence volume in ft^3
T = submergence time in minutes
Rs = rate of foam breakdown by sprinklers in cfm
Cn = compensation for normal foam shrinkage
CL = compensation for leakage

Rs = S x Q = 12,000 cfm

S = foam breakdown in cfm per gpm of sprinkler discharge
S=10 cfm/gpm

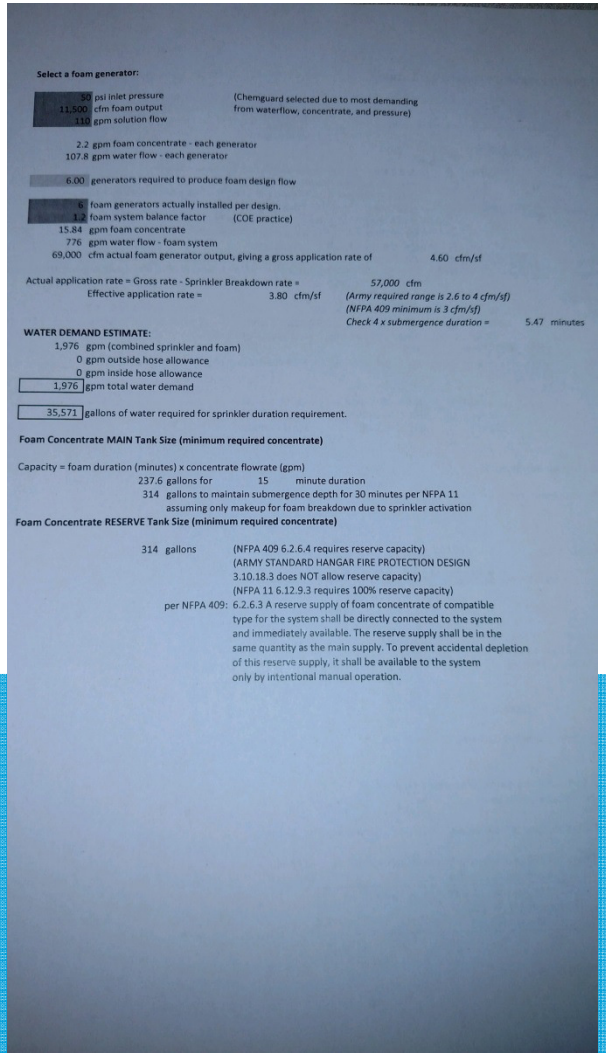
Q = estimated total discharge from maximum number of sprinklers expected to operate in gpm (includes inside hose)

Cn 1.15 (1.15 - normal foam shrinkage factor) NFPA 11 and App A Army

CL 2.5 (1.0 - building completely tight to the fill depth) NFPA 11
1.2 (1.2 - significant leakage/foam loss) NFPA 11

App A Army
Cannot be less than 2.0 for hangars < 15,000sf
2.5 for hangars < 30,000 sf
3.0 for all other hangars

2.00% Foam Concentrate Proportion



Select a foam generator:

50 psi inlet pressure
11,500 cfm foam output
110 gpm solution flow
(Chemguard selected due to most demanding from waterflow, concentrate, and pressure)

2.2 gpm foam concentrate - each generator
107.8 gpm water flow - each generator

6.00 generators required to produce foam design flow

6 foam generators actually installed per design.
1.2 foam system balance factor (COE practice)
15.84 gpm foam concentrate
776 gpm water flow - foam system
69,000 cfm actual foam generator output, giving a gross application rate of 4.60 cfm/sf

Actual application rate = Gross rate - Sprinkler Breakdown rate = 57,000 cfm
Effective application rate = 3.80 cfm/sf
(Army required range is 2.6 to 4 cfm/sf)
(NFPA 409 minimum is 3 cfm/sf)
Check 4 x submergence duration = 5.47 minutes

WATER DEMAND ESTIMATE:

1,976 gpm (combined sprinkler and foam)
0 gpm outside hose allowance
0 gpm inside hose allowance
1,976 gpm total water demand

35,571 gallons of water required for sprinkler duration requirement.

Foam Concentrate MAIN Tank Size (minimum required concentrate)

Capacity = foam duration (minutes) x concentrate flowrate (gpm)
237.6 gallons for 15 minute duration
314 gallons to maintain submergence depth for 30 minutes per NFPA 11 assuming only makeup for foam breakdown due to sprinkler activation

Foam Concentrate RESERVE Tank Size (minimum required concentrate)

314 gallons (NFPA 409 6.2.6.4 requires reserve capacity)
(ARMY STANDARD HANGAR FIRE PROTECTION DESIGN 3.10.18.3 does NOT allow reserve capacity)
(NFPA 11 6.12.9.3 requires 100% reserve capacity)

per NFPA 409: 6.2.6.3 A reserve supply of foam concentrate of compatible type for the system shall be directly connected to the system and immediately available. The reserve supply shall be in the same quantity as the main supply. To prevent accidental depletion of this reserve supply, it shall be available to the system only by intentional manual operation.

Design/Selection of Components

Select High Expansion Foam Generators

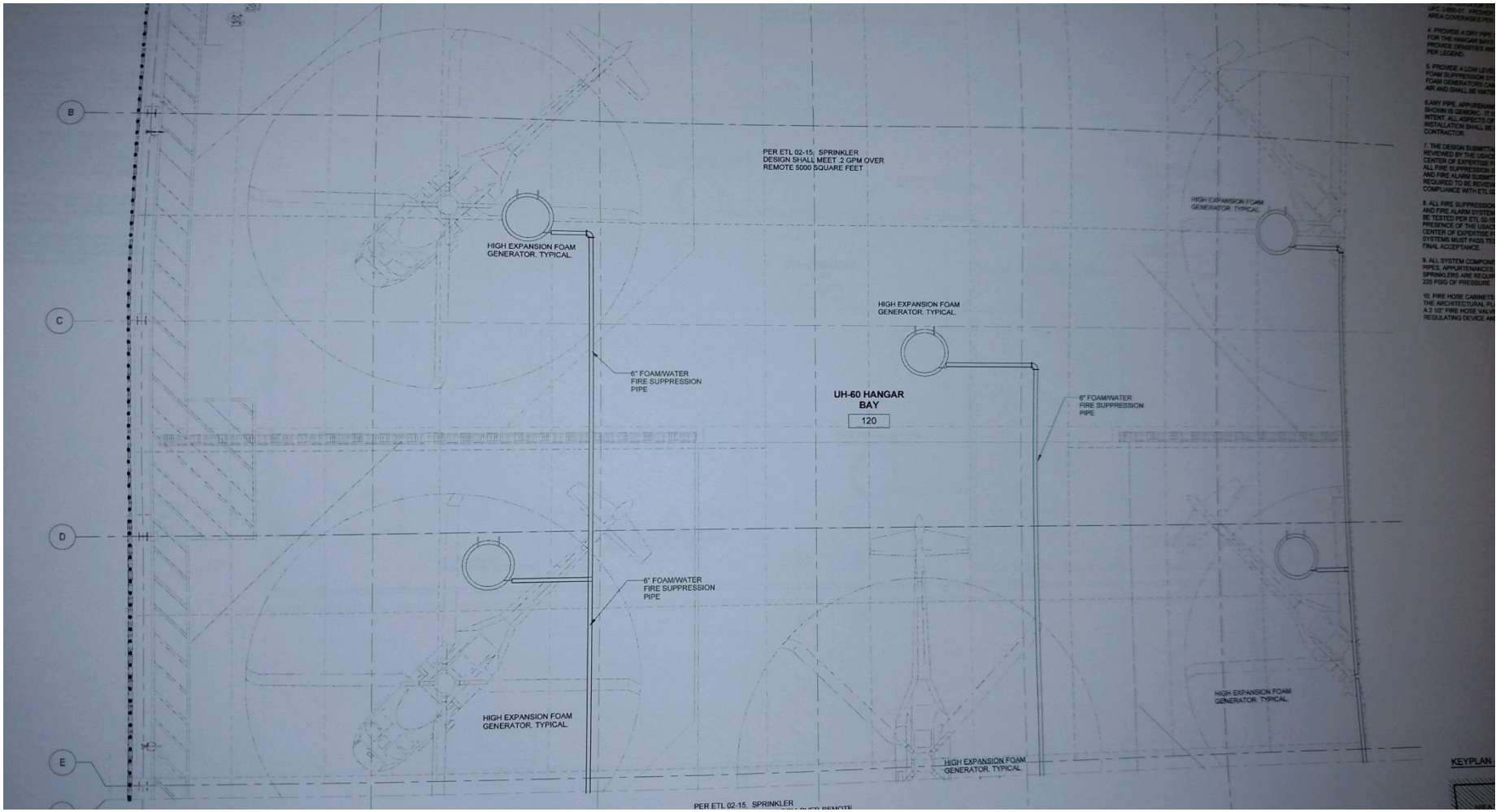
Select Fire Pumps (if necessary)

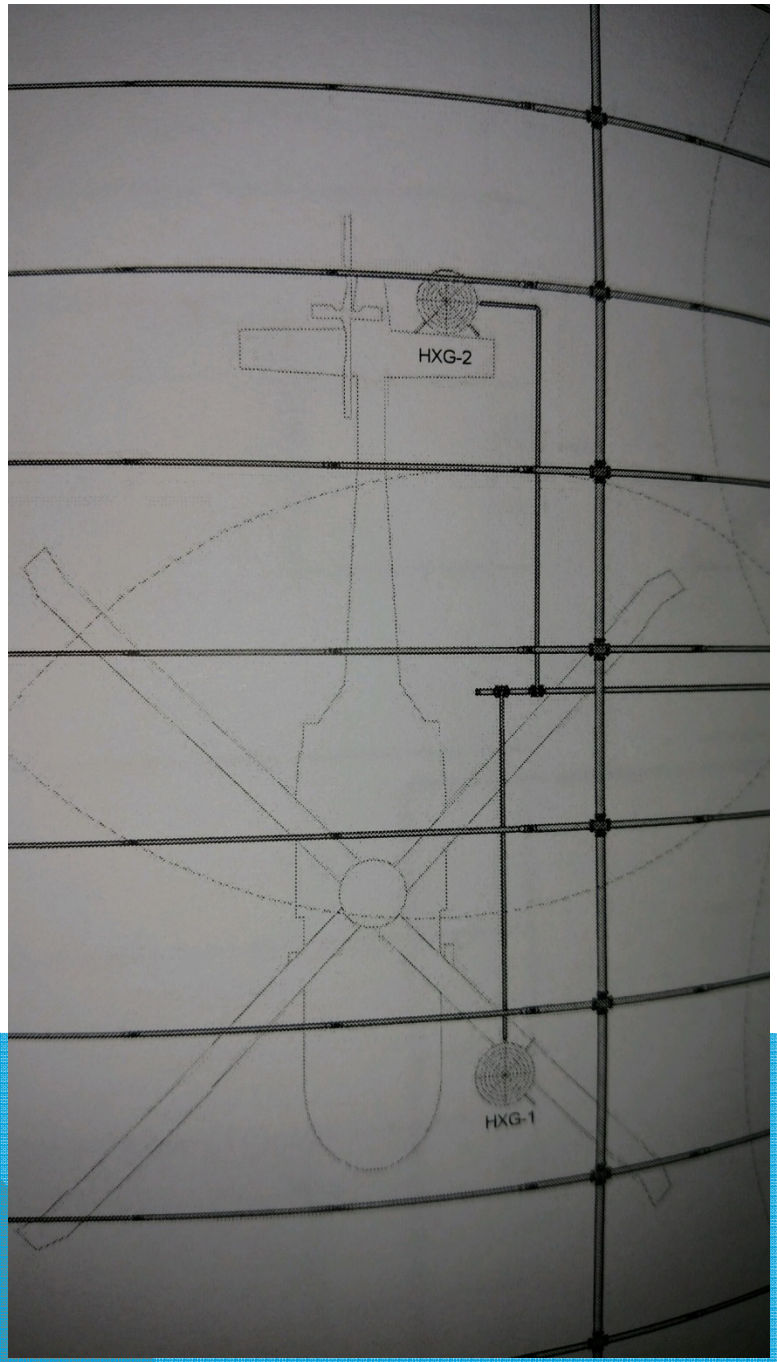
Select Foam Concentrate Tank Size

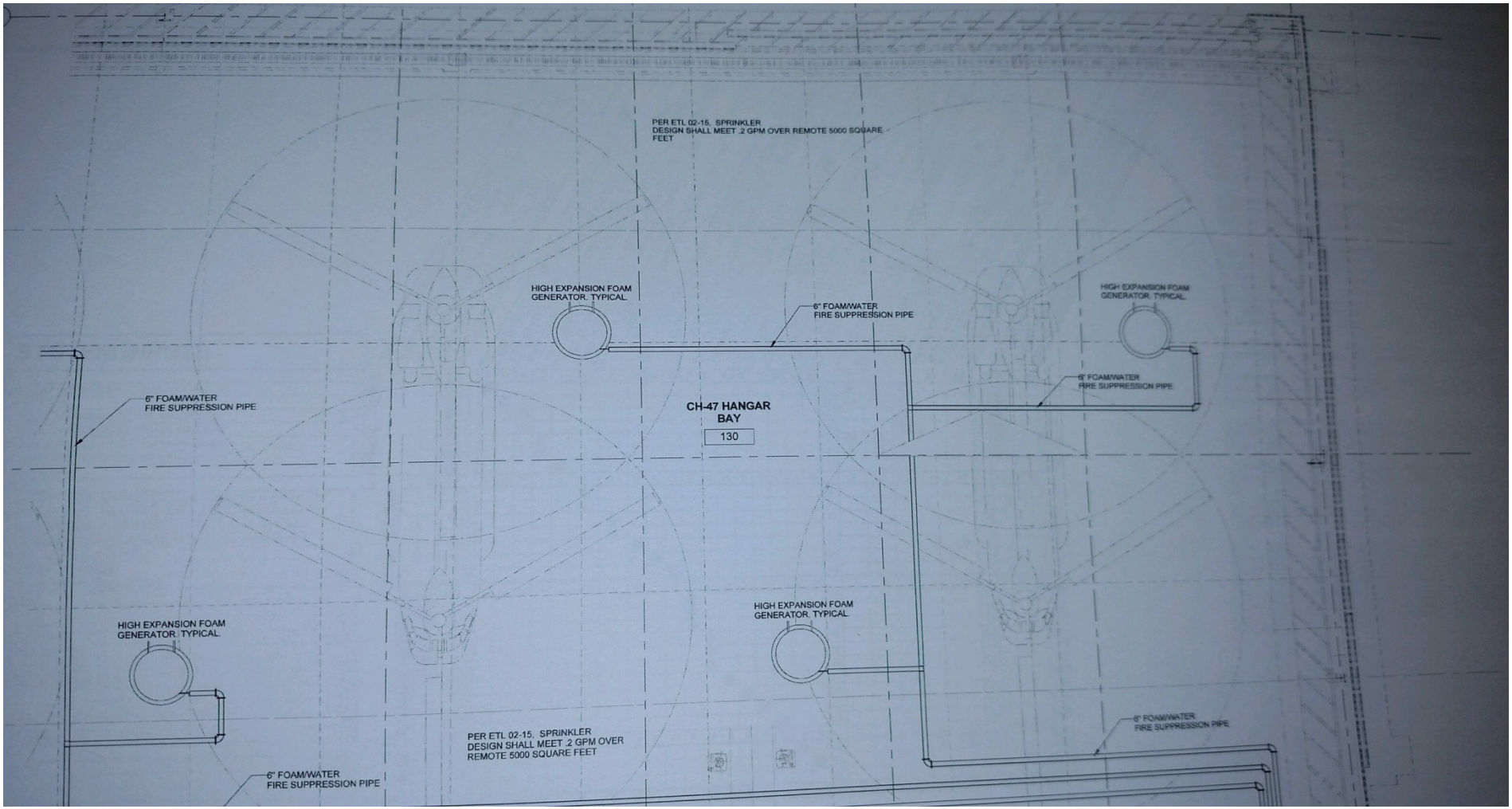
Select Foam Pumps

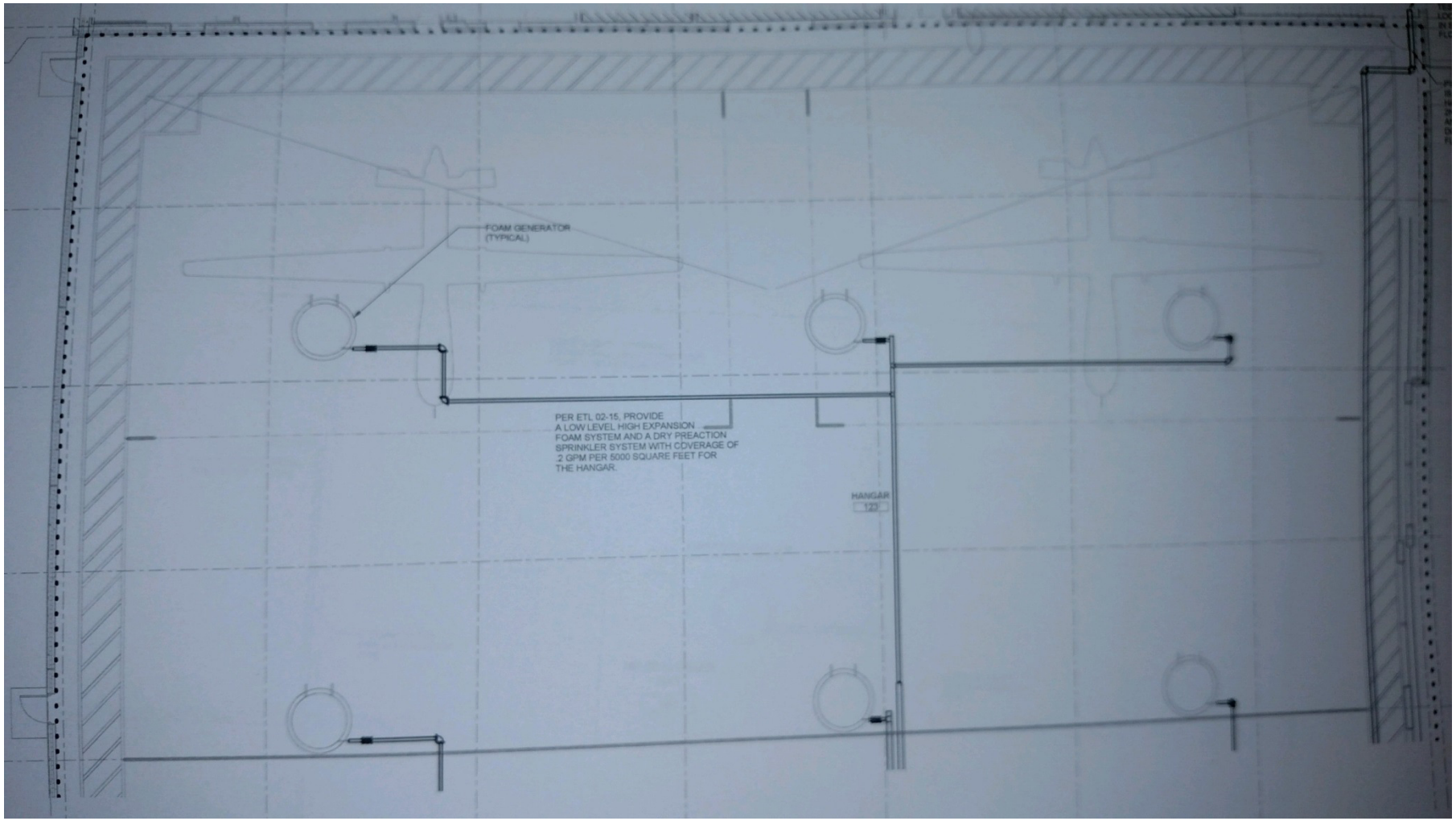
Select Deluge Valve (HEF Valve)

Start Layouts – Build Model

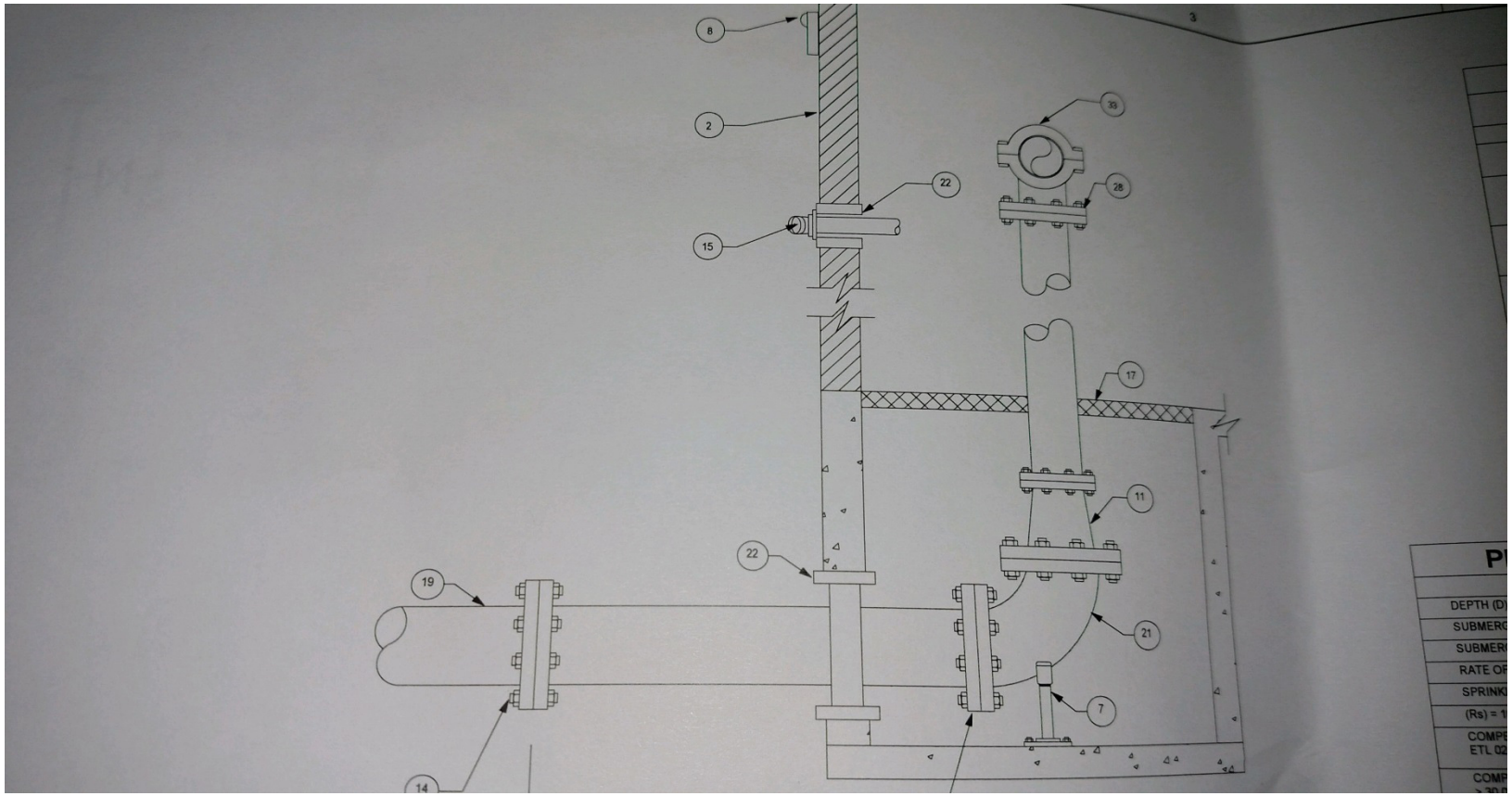

B
C
D
E
PER ETL 02-15, SPRINKLER
DESIGN SHALL MEET .2 GPM OVER
REMOTE 5000 SQUARE FEET
HIGH EXPANSION FOAM
GENERATOR. TYPICAL
HIGH EXPANSION FOAM
GENERATOR. TYPICAL
HIGH EXPANSION FOAM
GENERATOR. TYPICAL
6" FOAM/WATER
FIRE SUPPRESSION
PIPE
UH-60 HANGAR
BAY
120
6" FOAM/WATER
FIRE SUPPRESSION
PIPE
6" FOAM/WATER
FIRE SUPPRESSION
PIPE
HIGH EXPANSION FOAM
GENERATOR. TYPICAL
HIGH EXPANSION FOAM
GENERATOR. TYPICAL
KEYPLAN

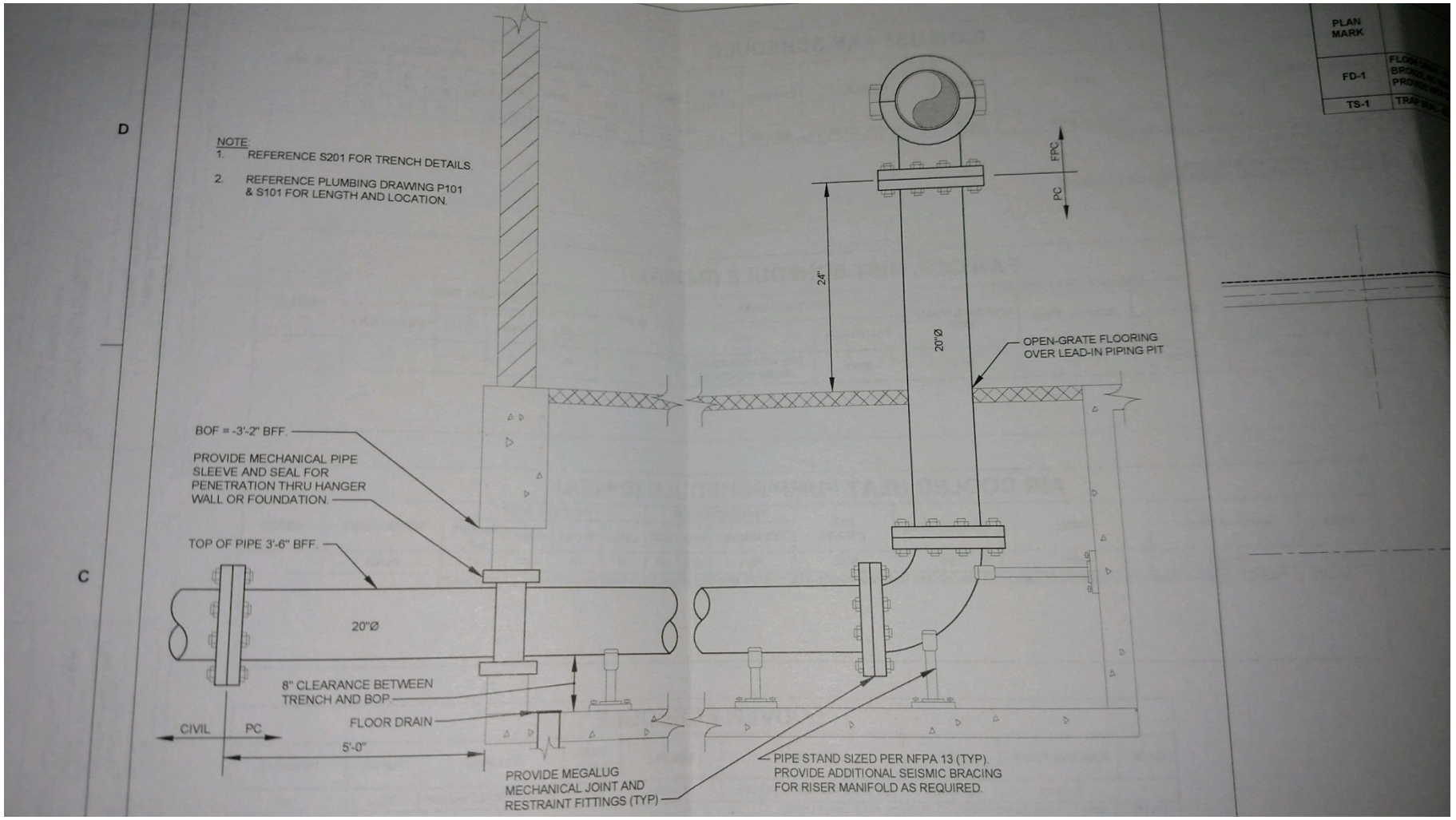

HXG-2
HXG-1

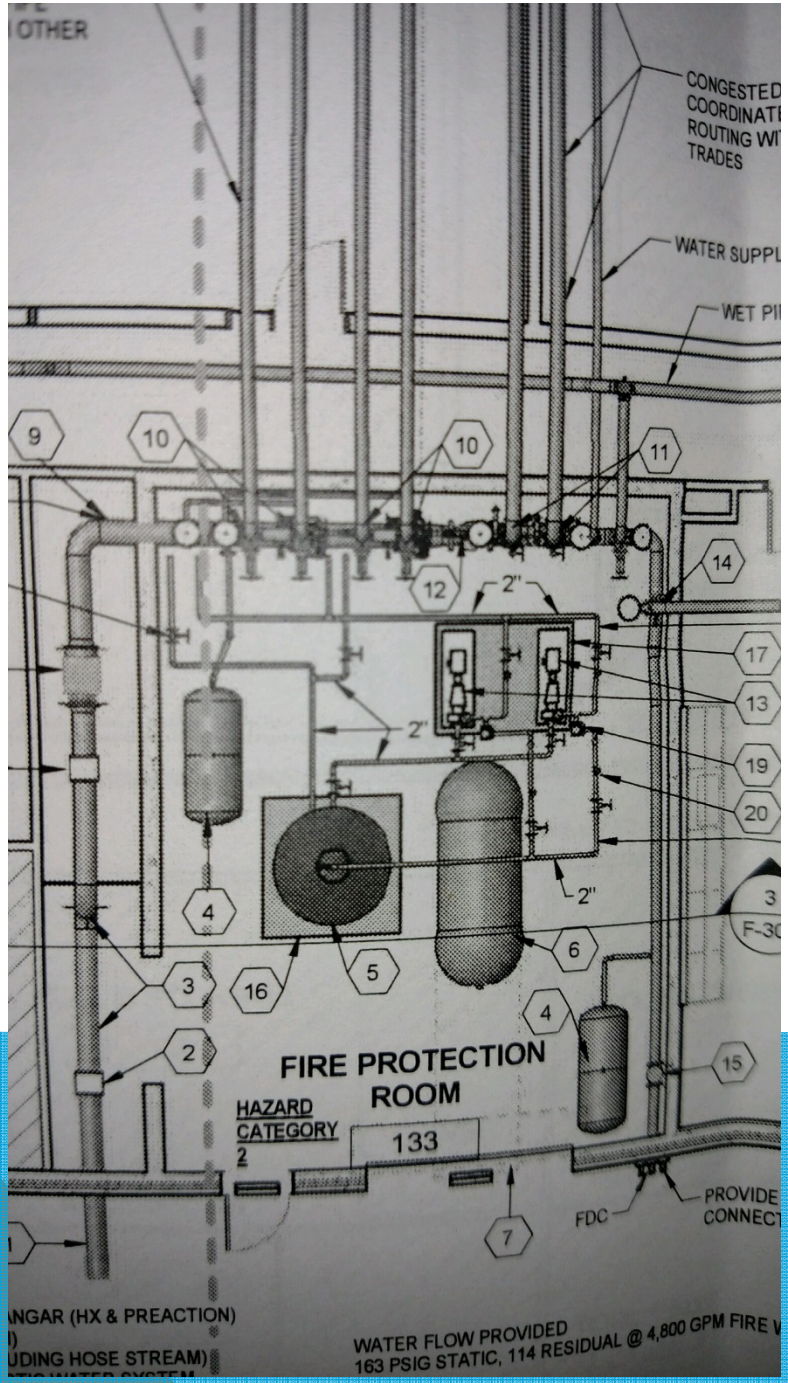

PER ETL 02-15, SPRINKLER
DESIGN SHALL MEET .2 GPM OVER REMOTE 5000 SQUARE
FEET
HIGH EXPANSION FOAM
GENERATOR. TYPICAL.
6" FOAM/WATER
FIRE SUPPRESSION PIPE
HIGH EXPANSION FOAM
GENERATOR. TYPICAL.
6" FOAM/WATER
FIRE SUPPRESSION PIPE
6" FOAM/WATER
FIRE SUPPRESSION PIPE
CH-47 HANGAR
BAY
130
HIGH EXPANSION FOAM
GENERATOR. TYPICAL.
HIGH EXPANSION FOAM
GENERATOR. TYPICAL.
PER ETL 02-15, SPRINKLER
DESIGN SHALL MEET .2 GPM OVER
REMOTE 5000 SQUARE FEET
6" FOAM/WATER
FIRE SUPPRESSION PIPE
6" FOAM/WATER
FIRE SUPPRESSION PIPE

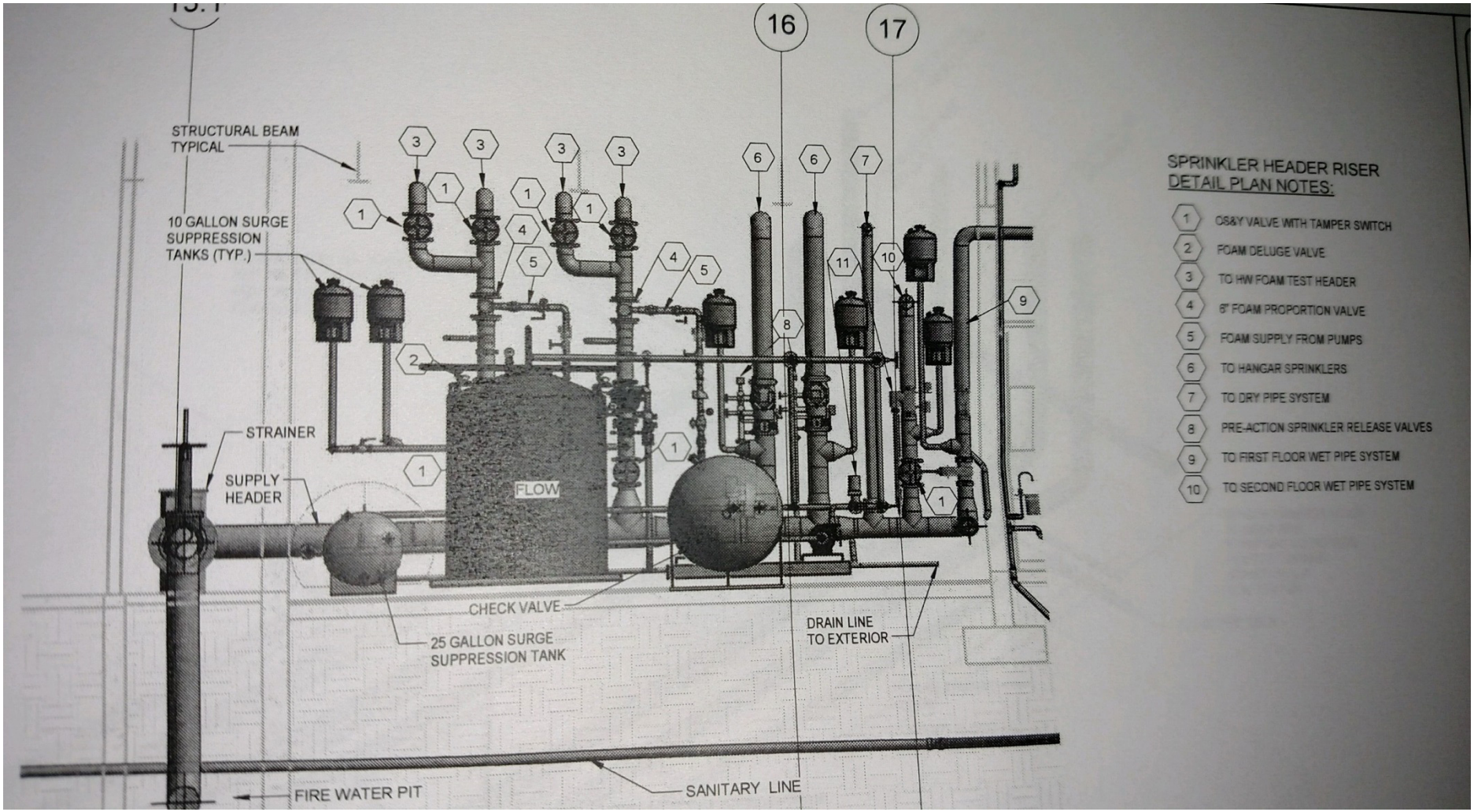

FOAM GENERATOR
(TYPICAL)
PER ETL 02-15, PROVIDE
A LOW LEVEL HIGH EXPANSION
FOAM SYSTEM AND A DRY PREACTION
SPRINKLER SYSTEM WITH COVERAGE OF
.2 GPM PER 5000 SQUARE FEET FOR
THE HANGAR.
HANGAR
123

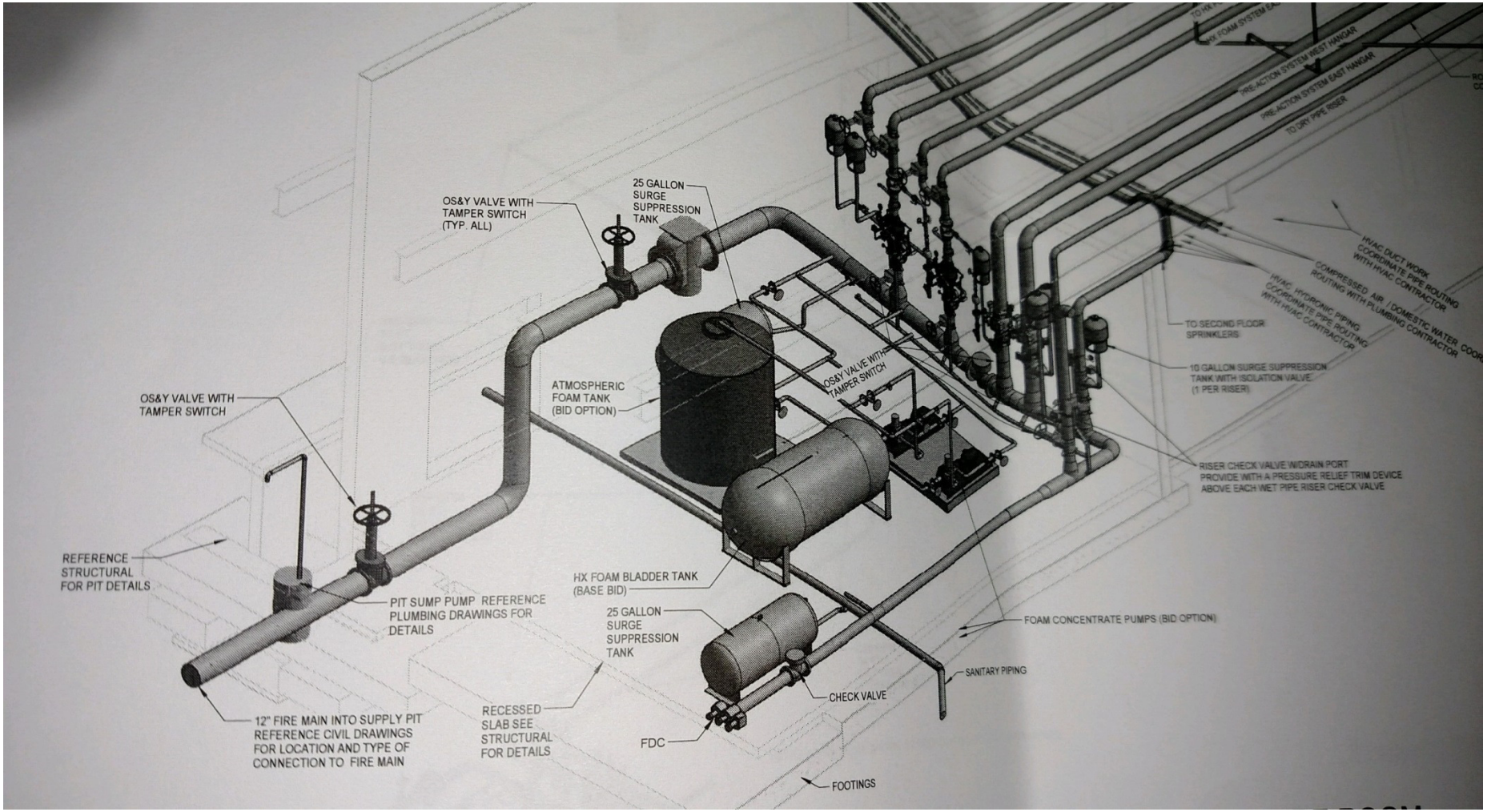
Examples of Water Service Entrances, Room Layouts, and Riser Information

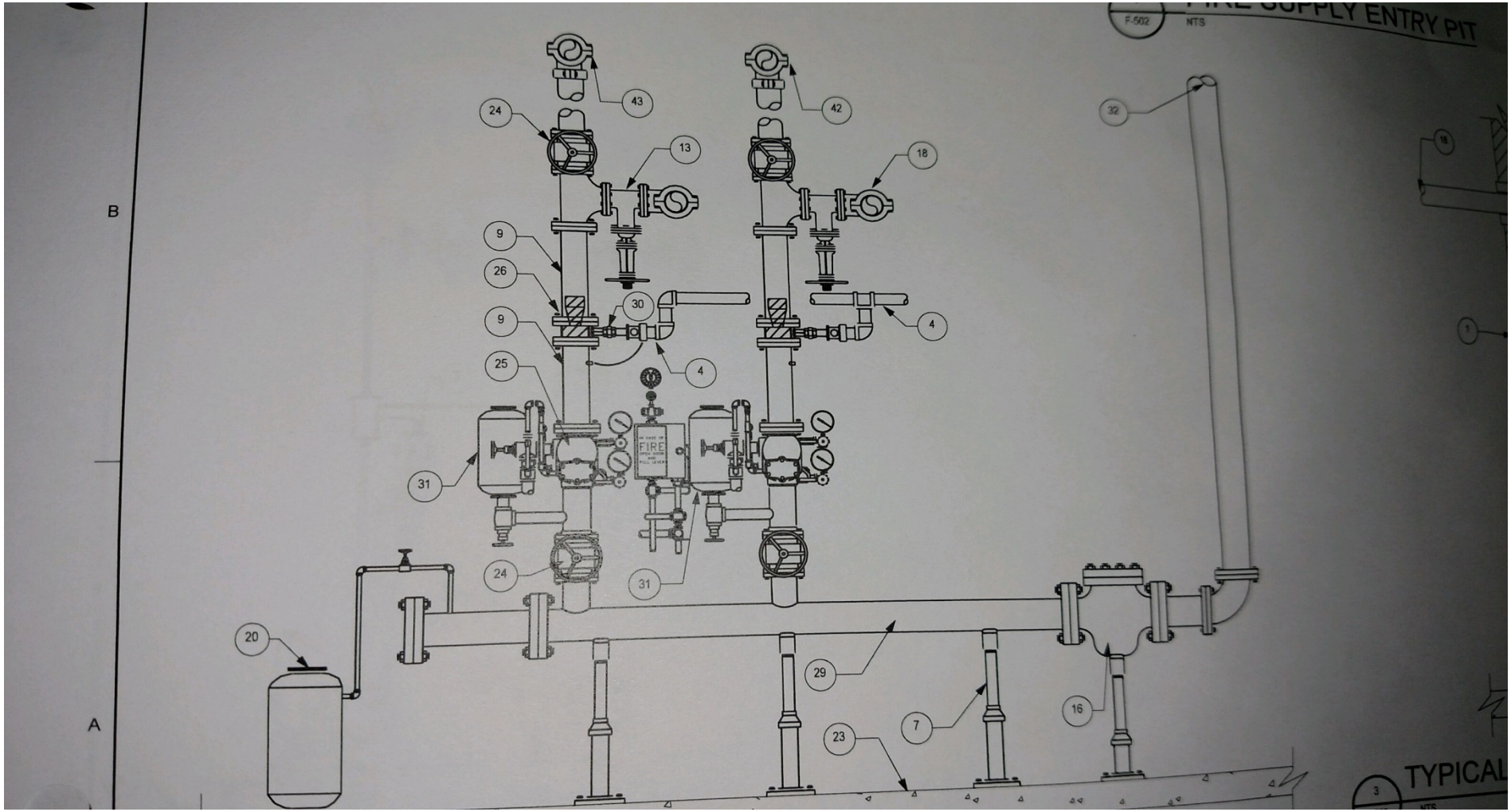



NOTE:
1. REFERENCE S201 FOR TRENCH DETAILS.
2. REFERENCE PLUMBING DRAWING P101 & S101 FOR LENGTH AND LOCATION.
PLAN MARK
FD-1
TS-1
FPC
PC
24"
20"Ø
OPEN-GRATE FLOORING OVER LEAD-IN PIPING PIT
BOF = -3'-2" BFF.
PROVIDE MECHANICAL PIPE SLEEVE AND SEAL FOR PENETRATION THRU HANGER WALL OR FOUNDATION.
TOP OF PIPE 3'-6" BFF.
20"Ø
8" CLEARANCE BETWEEN TRENCH AND BOP.
FLOOR DRAIN
CIVIL
PC
5'-0"
PROVIDE MEGALUG MECHANICAL JOINT AND RESTRAINT FITTINGS (TYP)
PIPE STAND SIZED PER NFPA 13 (TYP). PROVIDE ADDITIONAL SEISMIC BRACING FOR RISER MANIFOLD AS REQUIRED.
D
C


OTHER
CONGESTED
COORDINATE
ROUTING WI
TRADES
WATER SUPPL
WET PI
9
10
10
11
12
2"
14
17
13
2"
19
20
2"
4
3
F-30
6
3
16
5
4
2
FIRE PROTECTION
ROOM
15
HAZARD
CATEGORY
2
133
7
FDC
PROVIDE
CONNECT
ANGAR (HX & PREACTION)
UDING HOSE STREAM)
WATER FLOW PROVIDED
163 PSIG STATIC, 114 RESIDUAL @ 4,800 GPM FIRE

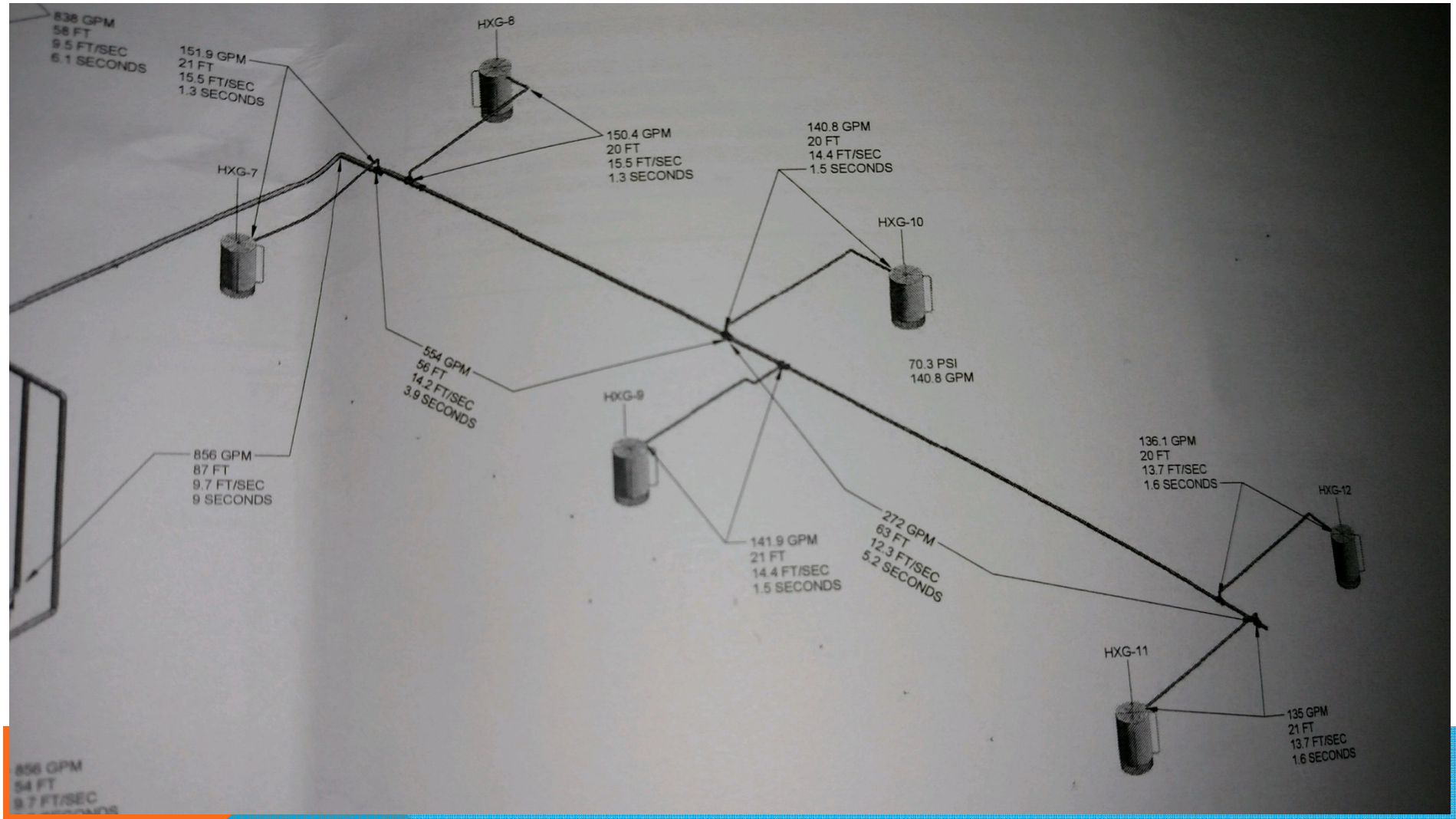

16
17
STRUCTURAL BEAM TYPICAL
10 GALLON SURGE SUPPRESSION TANKS (TYP.)
STRAINER
SUPPLY HEADER
FLOW
CHECK VALVE
25 GALLON SURGE SUPPRESSION TANK
DRAIN LINE TO EXTERIOR
FIRE WATER PIT
SANITARY LINE
SPRINKLER HEADER RISER DETAIL PLAN NOTES:
1 OS&Y VALVE WITH TAMPER SWITCH
2 FOAM DELUGE VALVE
3 TO HW FOAM TEST HEADER
4 6" FOAM PROPORTION VALVE
5 FOAM SUPPLY FROM PUMPS
6 TO HANGAR SPRINKLERS
7 TO DRY PIPE SYSTEM
8 PRE-ACTION SPRINKLER RELEASE VALVES
9 TO FIRST FLOOR WET PIPE SYSTEM
10 TO SECOND FLOOR WET PIPE SYSTEM

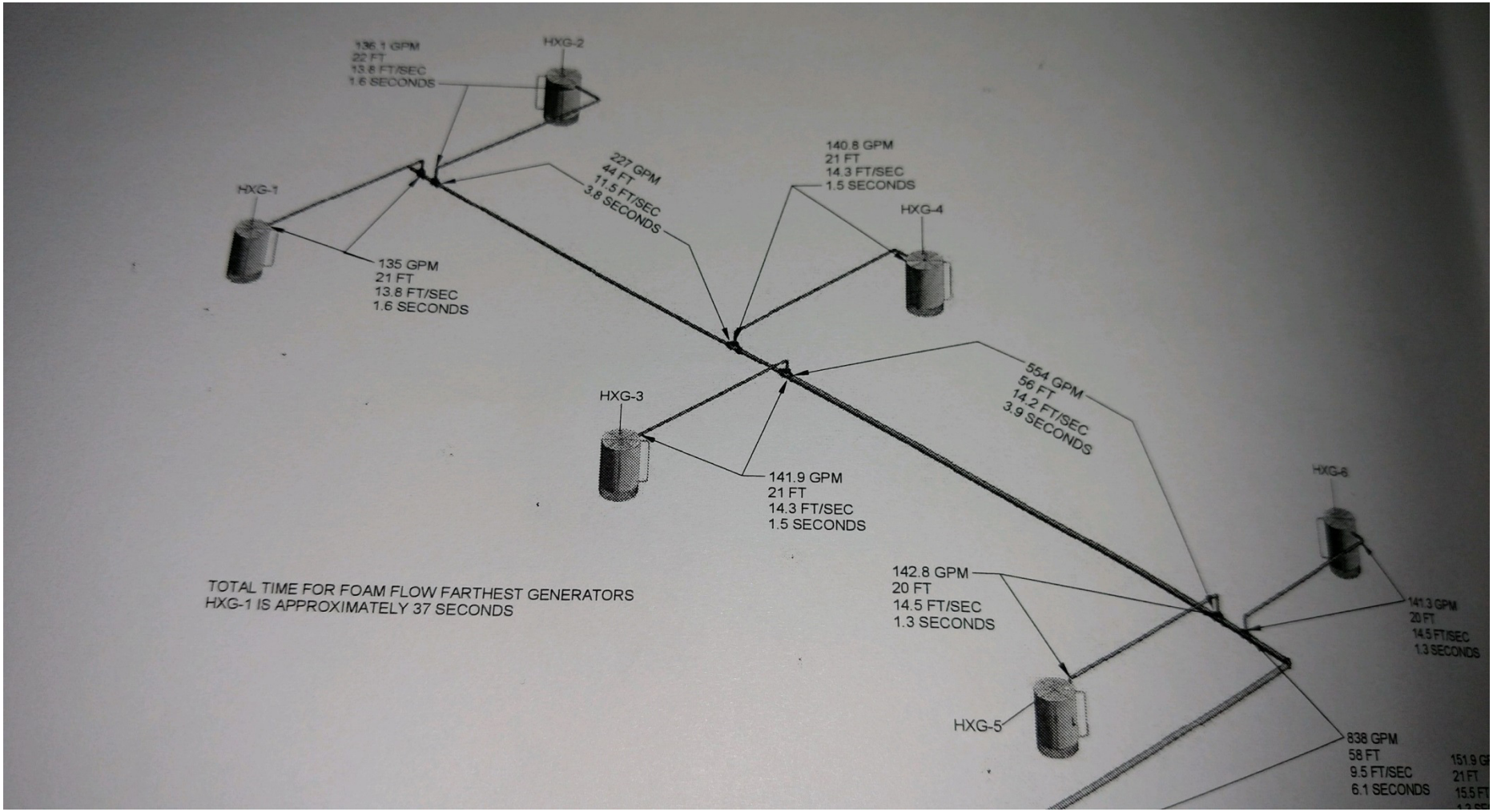

OS&Y VALVE WITH TAMPER SWITCH (TYP. ALL)
25 GALLON SURGE SUPPRESSION TANK
PRE-ACTION SYSTEM WEST HANGAR
PRE-ACTION SYSTEM EAST HANGAR
TO DRY PIPE RISER
HVAC DUCT WORK COORDINATE PIPE ROUTING WITH HVAC CONTRACTOR
COMPRESSED AIR / DOMESTIC WATER COORDINATE PIPE ROUTING WITH PLUMBING CONTRACTOR
HVAC HYDRONIC PIPING COORDINATE PIPE ROUTING WITH HVAC CONTRACTOR
TO SECOND FLOOR SPRINKLERS
10 GALLON SURGE SUPPRESSION TANK WITH ISOLATION VALVE (1 PER RISER)
OS&Y VALVE WITH TAMPER SWITCH
ATMOSPHERIC FOAM TANK (BID OPTION)
OS&Y VALVE WITH TAMPER SWITCH
RISER CHECK VALVE W/DRAIN PORT PROVIDE WITH A PRESSURE RELIEF TRIM DEVICE ABOVE EACH WET PIPE RISER CHECK VALVE
REFERENCE STRUCTURAL FOR PIT DETAILS
PIT SUMP PUMP REFERENCE PLUMBING DRAWINGS FOR DETAILS
HX FOAM BLADDER TANK (BASE BID)
25 GALLON SURGE SUPPRESSION TANK
FOAM CONCENTRATE PUMPS (BID OPTION)
SANITARY PIPING
CHECK VALVE
12" FIRE MAIN INTO SUPPLY PIT REFERENCE CIVIL DRAWINGS FOR LOCATION AND TYPE OF CONNECTION TO FIRE MAIN
RECESSED SLAB SEE STRUCTURAL FOR DETAILS
FDC
FOOTINGS


F-502
NTS
B
A
43
42
24
13
18
32
9
26
30
4
9
25
4
31
FIRE
24
31
20
29
16
7
23
TYPICAL


FIRE SPRINKLER WATER

Validate/Calculate System Design




136.1 GPM
22 FT
13.8 FT/SEC
1.6 SECONDS
HXG-2
227 GPM
44 FT
11.5 FT/SEC
3.8 SECONDS
140.8 GPM
21 FT
14.3 FT/SEC
1.5 SECONDS
HXG-4
HXG-1
135 GPM
21 FT
13.8 FT/SEC
1.6 SECONDS
554 GPM
56 FT
14.2 FT/SEC
3.9 SECONDS
HXG-3
141.9 GPM
21 FT
14.3 FT/SEC
1.5 SECONDS
HXG-6
TOTAL TIME FOR FOAM FLOW FARTHEST GENERATORS
HXG-1 IS APPROXIMATELY 37 SECONDS
142.8 GPM
20 FT
14.5 FT/SEC
1.3 SECONDS
141.3 GPM
20 FT
14.5 FT/SEC
1.3 SECONDS
HXG-5
838 GPM
58 FT
9.5 FT/SEC
6.1 SECONDS

Time Analysis for : Headset_1

Dry pipe system

System Volume	768.6 gal
Downstream DPV Volume	768.6 gal
Fluid	Water @ 60F (15.6C)
Gas	Air @ 40°F and 0psi
Differential Trip Ratio	0 (Deluge valve)
Accelerator	Not Used

Headset Time Parameters

Trip Time	N/A
Fluid Delivery Time	18.36s
Operating Time	N/A
Required Fluid Delivery Time	60s
Safety Factor	69.4%

Water Supply Parameters

Flow (gpm)	Pressure (psi)
0	136
2800	128

Parameters of the 12 Open Heads

Head#	K-Factor	Orifice	Minimum Operating Pressure	Transit Time	Fluid Delivery Time	Oper. Time SHALL NOT exceed 60s	Open Time
	(gpm/psi½)	(in)	(psi)	(s)	(s)	(s)	(s)
N1	16.8	0.772	50	18.19	18.19	N/A	0
N10	16.8	0.772	50	5.855	5.855	N/A	0
N11	16.8	0.772	50	2.856	2.856	N/A	0
N12	16.8	0.772	50	3.917	3.917	N/A	0
N2	16.8	0.772	50	18.36	18.36	N/A	0
N3	16.8	0.772	50	14.05	14.05	N/A	0
N4	16.8	0.772	50	15.27	15.27	N/A	0
N5	16.8	0.772	50	11.4	11.4	N/A	0
N6	16.8	0.772	50	12.09	12.09	N/A	0
N7	16.8	0.772	50	7.675	7.675	N/A	0
N8	16.8	0.772	50	9.271	9.271	N/A	0
N9	16.8	0.772	50	5.115	5.115	N/A	0

Protocol: NOT USED

NOT USED Statement

Modelling Assumptions

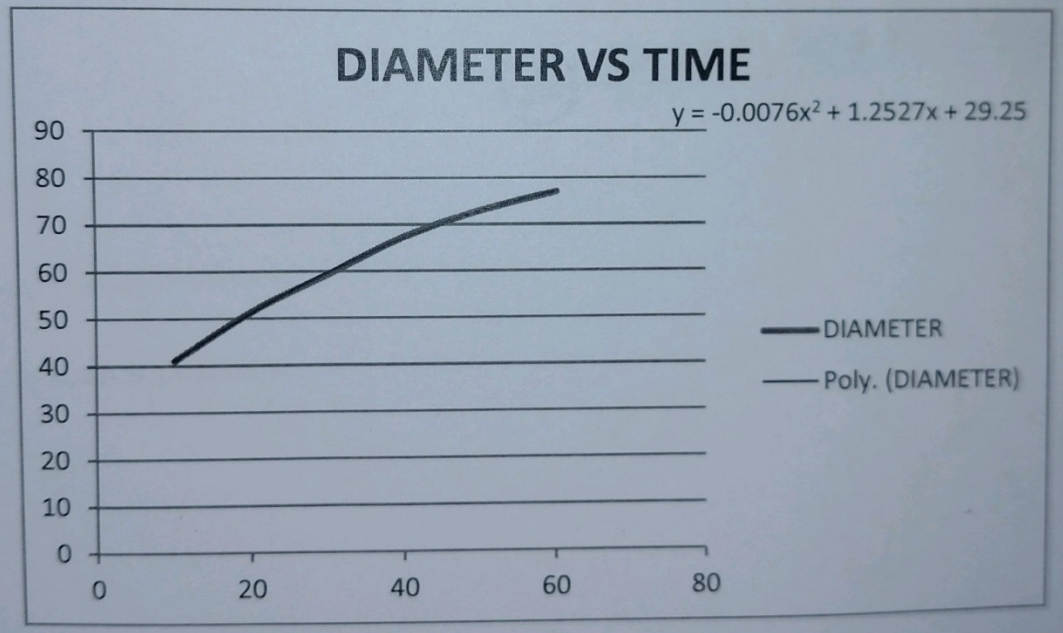
1. Fluid is incompressible.
2. Pipes do not suffer deformation.
3. Fluid front is perpendicular to pipe centerline.

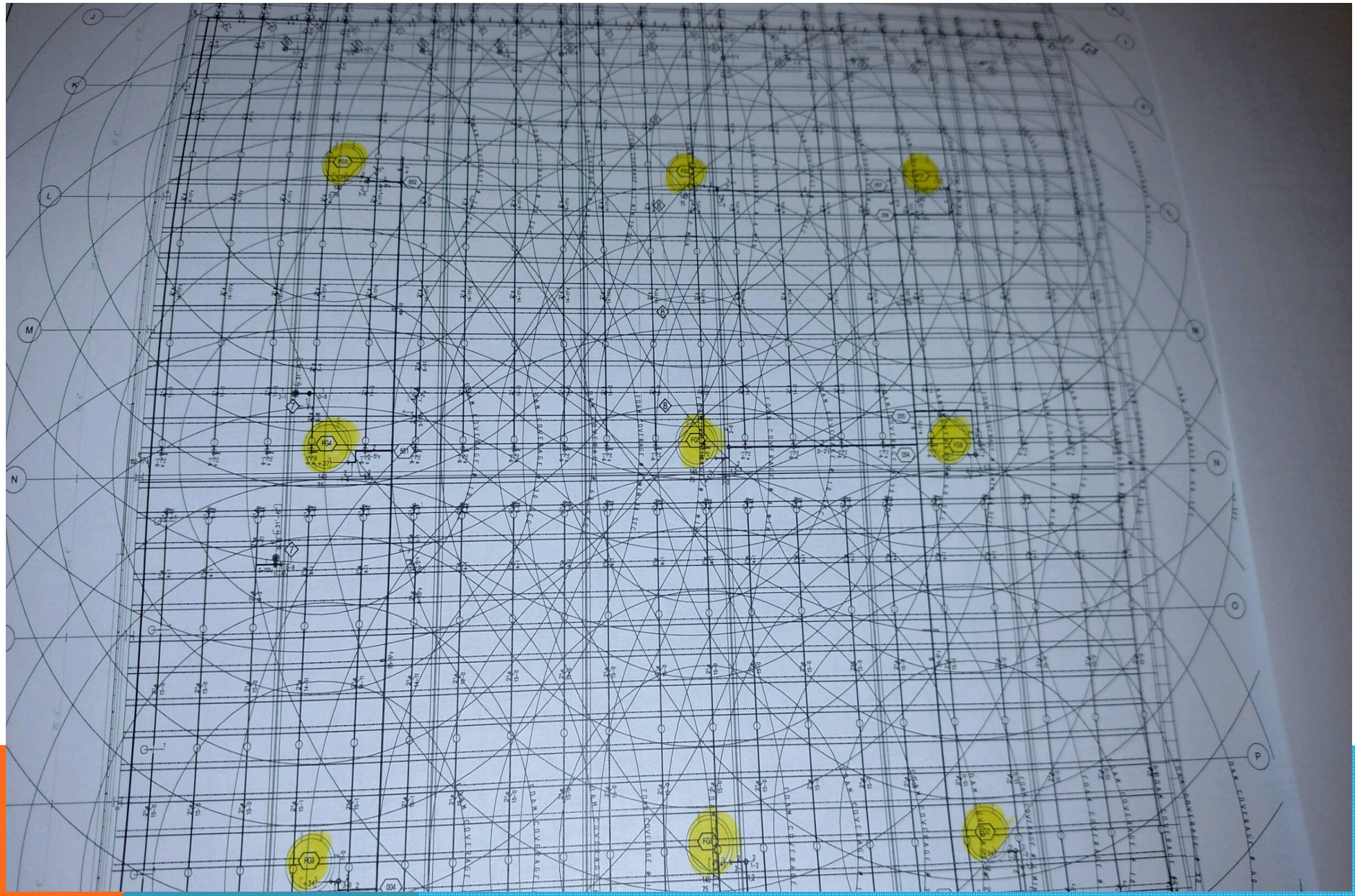
TABLE 1

HEF GENERATOR	OPERATING TIME 50 PSI (SEC)	TIME TO DEVELOP FOAM (SEC)	DIAMETER OF FOAM @ 1MINUTE (FT)
N1	18.19	41.81	68.36
N10	5.855	54.145	74.83
N11	2.856	57.144	76.05
N12	3.917	56.083	75.64
N2	18.36	41.64	68.25
N3	14.05	45.95	70.79
N4	15.27	44.73	70.10
N5	11.4	48.6	72.21
N6	12.09	47.91	71.85
N7	7.675	52.325	74.02
N8	9.271	50.729	73.27
N9	5.115	54.885	75.14

OPERATING TIME FROM FLUID DELIVERY CALCULATIONS FROM ANSUL
TIME TO DEVELOP FOAM = 60 SECONDS LESS OPERATING TIME TO REACH 50 PSI AT GENERATOR
DIAMETER FROM FOAM SPREAD DATA TABLE FOR JET-X15 GENERATOR WITH JET-X 2% FOAM @ 50 PSI

TIME	DIAMETER
10	41
20	51.5
30	59.5
40	67.5
50	73
60	77





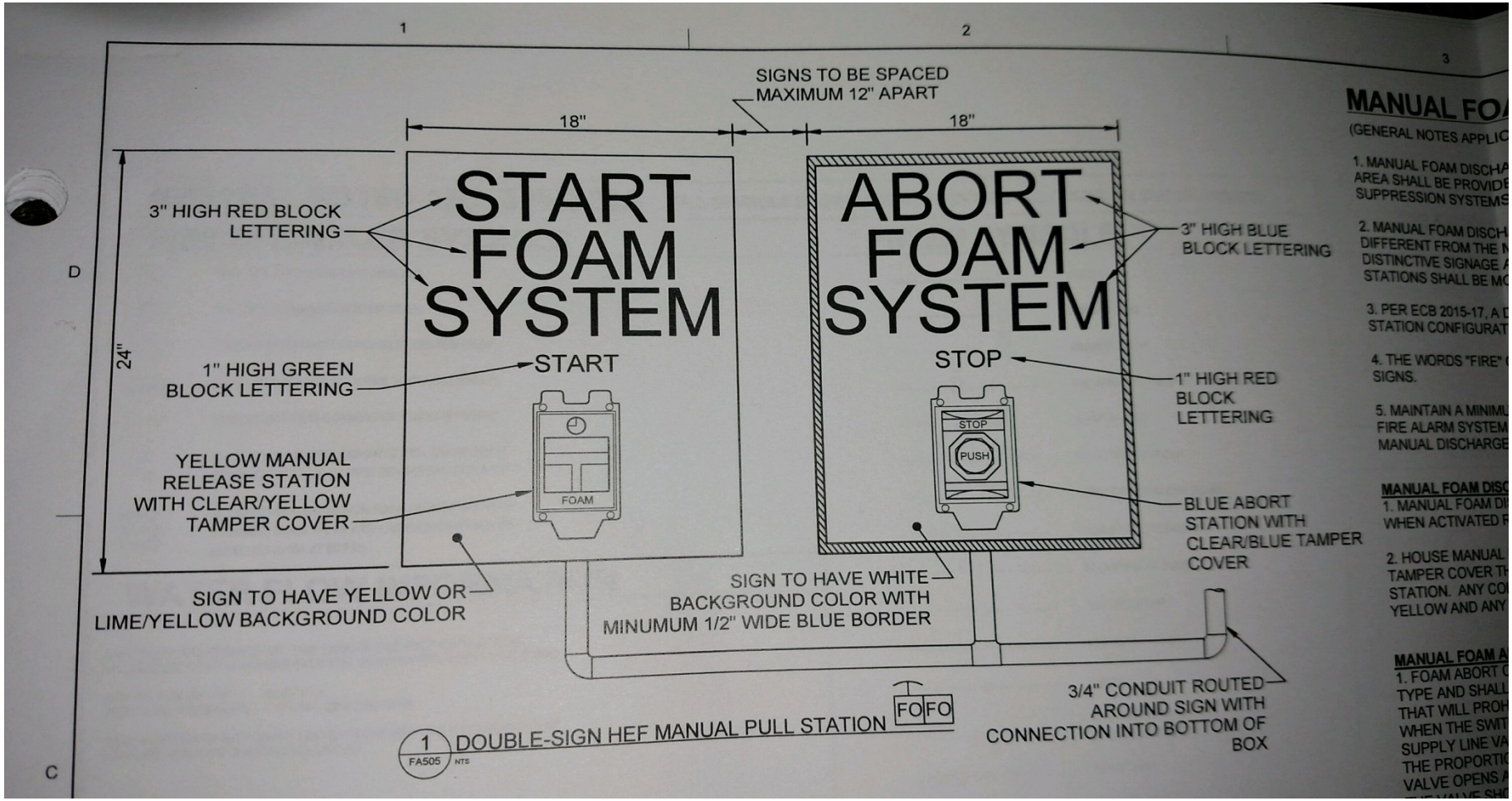
Activation of System

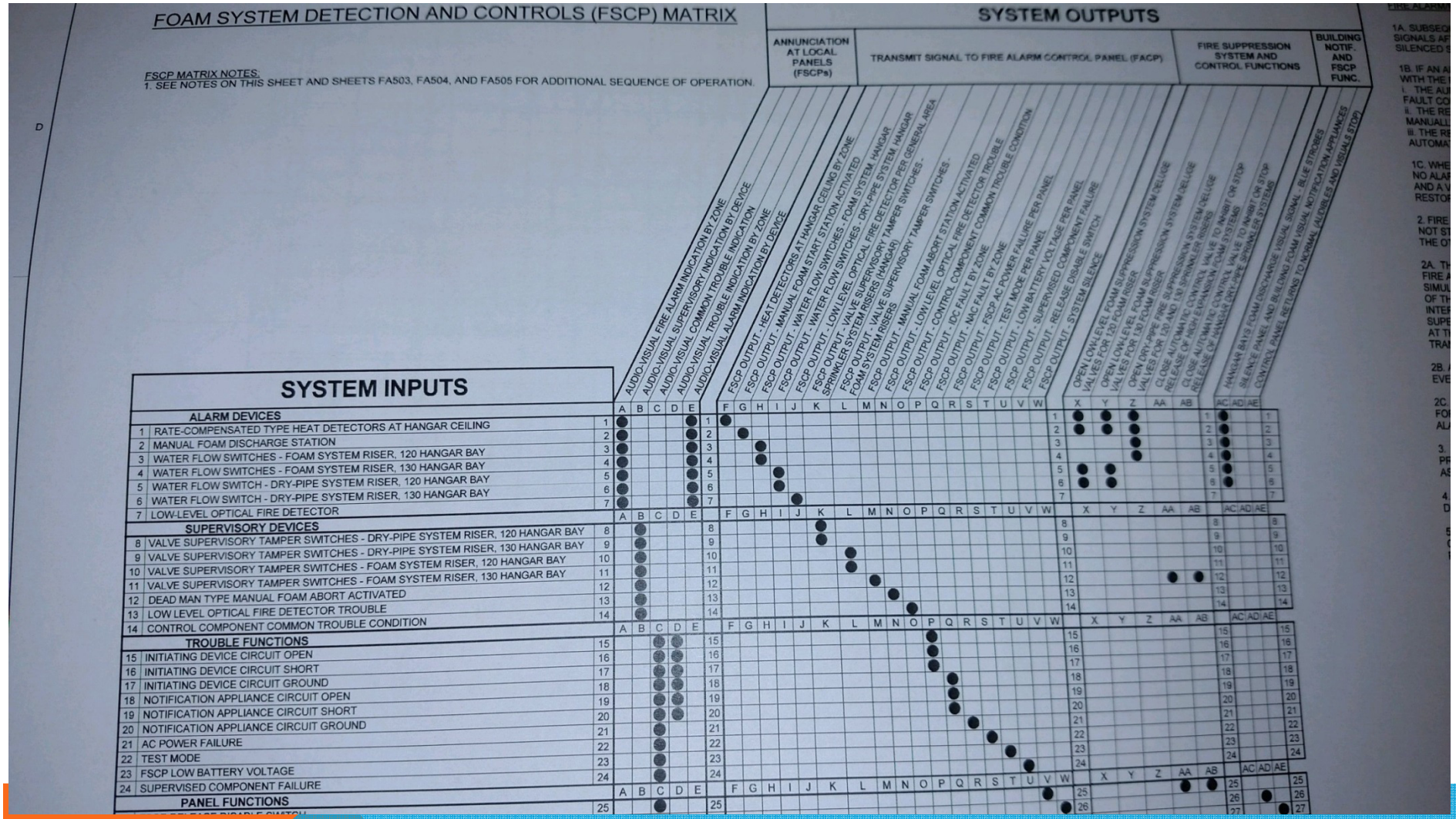
ECB 2015-17 (Typical) Changes to Reduce False Activation of High Expansion Foam Systems in Army Hangars

"With the exception of a manual foam release station, the cross-zoning of two automatic initiating devices in the hangar bay is required to release the high expansion foam. This is permitted to be the cross-zoning of a sprinkler water flow switch and an optical flame detector, or two optical flame detectors"

Note: Water flow switch is activated by heat detectors at the ceiling of the hangar bays.

"Activation of the first automatic initiating device shall annunciate at the local Panel and send a general alarm to the fire alarm control panel and the Fire department. Activation of the second automatic initiating device shall In addition to the above, release the high expansion foam."


SIGNS TO BE SPACED
MAXIMUM 12" APART
18"
18"
START
FOAM
SYSTEM
ABORT
FOAM
SYSTEM
3" HIGH RED BLOCK
LETTERING
3" HIGH BLUE
BLOCK LETTERING
24"
1" HIGH GREEN
BLOCK LETTERING
START
STOP
1" HIGH RED
BLOCK
LETTERING
FOAM
STOP
PUSH
YELLOW MANUAL
RELEASE STATION
WITH CLEAR/YELLOW
TAMPER COVER
BLUE ABORT
STATION WITH
CLEAR/BLUE TAMPER
COVER
SIGN TO HAVE YELLOW OR
LIME/YELLOW BACKGROUND COLOR
SIGN TO HAVE WHITE
BACKGROUND COLOR WITH
MINUMUM 1/2" WIDE BLUE BORDER
FO FO
3/4" CONDUIT ROUTED
AROUND SIGN WITH
CONNECTION INTO BOTTOM OF
BOX
1
FA505
NTS
DOUBLE-SIGN HEF MANUAL PULL STATION
MANUAL FOA
(GENERAL NOTES APPLIC
1. MANUAL FOAM DISCHA
AREA SHALL BE PROVIDE
SUPPRESSION SYSTEMS
2. MANUAL FOAM DISCH
DIFFERENT FROM THE N
DISTINCTIVE SIGNAGE A
STATIONS SHALL BE MO
3. PER ECB 2015-17, A D
STATION CONFIGURAT
4. THE WORDS "FIRE"
SIGNS.
5. MAINTAIN A MINIMU
FIRE ALARM SYSTEM
MANUAL DISCHARGE
MANUAL FOAM DISC
1. MANUAL FOAM DI
WHEN ACTIVATED F
2. HOUSE MANUAL
TAMPER COVER TH
STATION. ANY CO
YELLOW AND ANY
MANUAL FOAM A
1. FOAM ABORT C
TYPE AND SHALL
THAT WILL PROH
WHEN THE SWIT
SUPPLY LINE VA
THE PROPORTIO
VALVE OPENS A



FOAM SYSTEM DETECTION AND CONTROLS (FSCP) MATRIX

FSCP MATRIX NOTES:
1. SEE NOTES ON THIS SHEET AND SHEETS FA503, FA504, AND FA505 FOR ADDITIONAL SEQUENCE OF OPERATION.

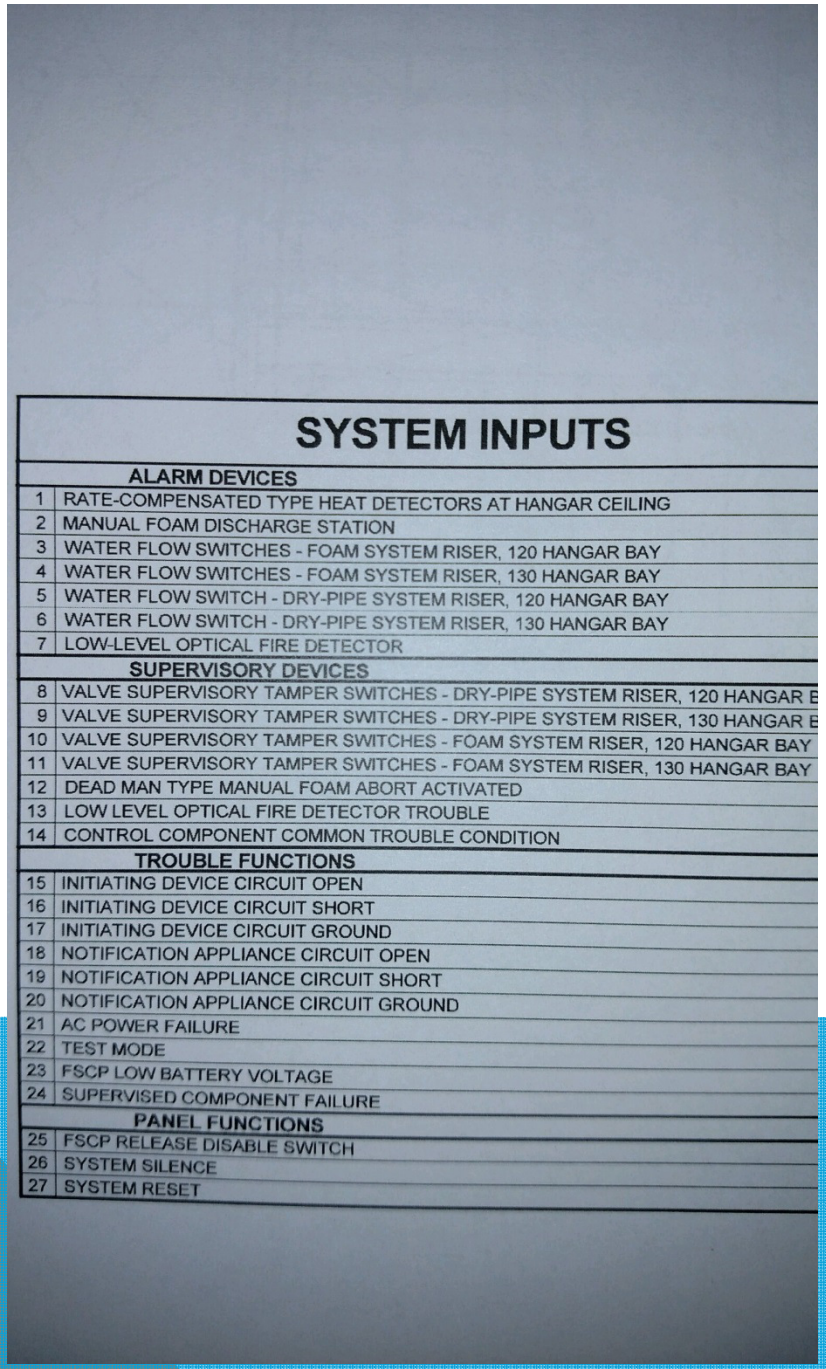
SYSTEM INPUTS

	ALARM DEVICES	
1	RATE-COMPENSATED TYPE HEAT DETECTORS AT HANGAR CEILING	1
2	MANUAL FOAM DISCHARGE STATION	2
3	WATER FLOW SWITCHES - FOAM SYSTEM RISER, 120 HANGAR BAY	3
4	WATER FLOW SWITCHES - FOAM SYSTEM RISER, 130 HANGAR BAY	4
5	WATER FLOW SWITCH - DRY-PIPE SYSTEM RISER, 120 HANGAR BAY	5
6	WATER FLOW SWITCH - DRY-PIPE SYSTEM RISER, 130 HANGAR BAY	6
7	LOW-LEVEL OPTICAL FIRE DETECTOR	7
	SUPERVISORY DEVICES	
8	VALVE SUPERVISORY TAMPER SWITCHES - DRY-PIPE SYSTEM RISER, 120 HANGAR BAY	8
9	VALVE SUPERVISORY TAMPER SWITCHES - DRY-PIPE SYSTEM RISER, 130 HANGAR BAY	9
10	VALVE SUPERVISORY TAMPER SWITCHES - FOAM SYSTEM RISER, 120 HANGAR BAY	10
11	VALVE SUPERVISORY TAMPER SWITCHES - FOAM SYSTEM RISER, 130 HANGAR BAY	11
12	DEAD MAN TYPE MANUAL FOAM ABORT ACTIVATED	12
13	LOW LEVEL OPTICAL FIRE DETECTOR TROUBLE	13
14	CONTROL COMPONENT COMMON TROUBLE CONDITION	14
	TROUBLE FUNCTIONS	
15	INITIATING DEVICE CIRCUIT OPEN	15
16	INITIATING DEVICE CIRCUIT SHORT	16
17	INITIATING DEVICE CIRCUIT GROUND	17
18	NOTIFICATION APPLIANCE CIRCUIT OPEN	18
19	NOTIFICATION APPLIANCE CIRCUIT SHORT	19
20	NOTIFICATION APPLIANCE CIRCUIT GROUND	20
21	AC POWER FAILURE	21
22	TEST MODE	22
23	FSCP LOW BATTERY VOLTAGE	23
24	SUPERVISED COMPONENT FAILURE	24
	PANEL FUNCTIONS	25

SYSTEM OUTPUTS

ANNUNCIATION AT LOCAL PANELS (FSCPs)	TRANSMIT SIGNAL TO FIRE ALARM CONTROL PANEL (FACP)	FIRE SUPPRESSION SYSTEM AND CONTROL FUNCTIONS	BUILDING NOTIF. AND FSCP FUNC.

- A: AUDIO-VISUAL FIRE ALARM INDICATION BY ZONE
- B: AUDIO-VISUAL SUPERVISORY INDICATION BY DEVICE
- C: AUDIO-VISUAL COMMON TROUBLE INDICATION
- D: AUDIO-VISUAL TROUBLE INDICATION BY ZONE
- E: AUDIO-VISUAL ALARM INDICATION BY DEVICE
- F: FSCP OUTPUT - HEAT DETECTORS AT HANGAR CEILING BY ZONE
- G: FSCP OUTPUT - MANUAL FOAM START STATION ACTIVATED
- H: FSCP OUTPUT - WATER FLOW SWITCHES - FOAM SYSTEM, HANGAR SPRINKLER SYSTEM RISERS (HANGAR)
- I: FSCP OUTPUT - LOW LEVEL OPTICAL FIRE DETECTOR PER GENERAL AREA
- J: FSCP OUTPUT - VALVE SUPERVISORY TAMPER SWITCHES - FOAM SYSTEM RISERS
- K: FSCP OUTPUT - VALVE SUPERVISORY TAMPER SWITCHES - FOAM SYSTEM RISERS (HANGAR)
- L: FSCP OUTPUT - MANUAL FOAM ABORT STATION ACTIVATED
- M: FSCP OUTPUT - LOW LEVEL OPTICAL FIRE DETECTOR TROUBLE
- N: FSCP OUTPUT - CONTROL COMPONENT COMMON TROUBLE CONDITION
- O: FSCP OUTPUT - IDC FAULT BY ZONE
- P: FSCP OUTPUT - NAC FAULT BY ZONE
- Q: FSCP OUTPUT - FSCP AC POWER FAILURE PER PANEL
- R: FSCP OUTPUT - TEST MODE PER PANEL
- S: FSCP OUTPUT - LOW BATTERY VOLTAGE PER PANEL
- T: FSCP OUTPUT - SUPERVISED COMPONENT FAILURE
- U: FSCP OUTPUT - RELEASE DISABLE SWITCH
- V: FSCP OUTPUT - SYSTEM SILENCE
- W: OPEN LOW-LEVEL FOAM SUPPRESSION SYSTEM DELUGE VALVES FOR 120 FOAM RISER
- X: OPEN LOW-LEVEL FOAM SUPPRESSION SYSTEM DELUGE VALVES FOR 130 FOAM RISER
- Y: OPEN DRY-PIPE FIRE SUPPRESSION SYSTEM DELUGE VALVES FOR 120 AND 130 SPRINKLER RISERS
- Z: CLOSE AUTOMATIC CONTROL VALVE TO INHIBIT OR STOP RELEASE OF FOAM EXPANSION FOAM SYSTEMS
- AA: CLOSE AUTOMATIC CONTROL VALVE TO INHIBIT OR STOP RELEASE OF HANGAR DRY-PIPE SPRINKLER SYSTEMS
- AB: HANGAR BAYS FOAM DISCHARGE VISUAL SIGNAL, BLUE STROBES
- AC: SILENCE PANEL AND BUILDING FOAM VISUAL NOTIFICATION APPLIANCES
- AD: CONTROL PANEL RETURNS TO NORMAL (AUDIBLES AND VISUALS STOP)
- AE:



SYSTEM INPUTS

	ALARM DEVICES
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6	WATER FLOW SWITCH - DRY-PIPE SYSTEM RISER, 130 HANGAR BAY
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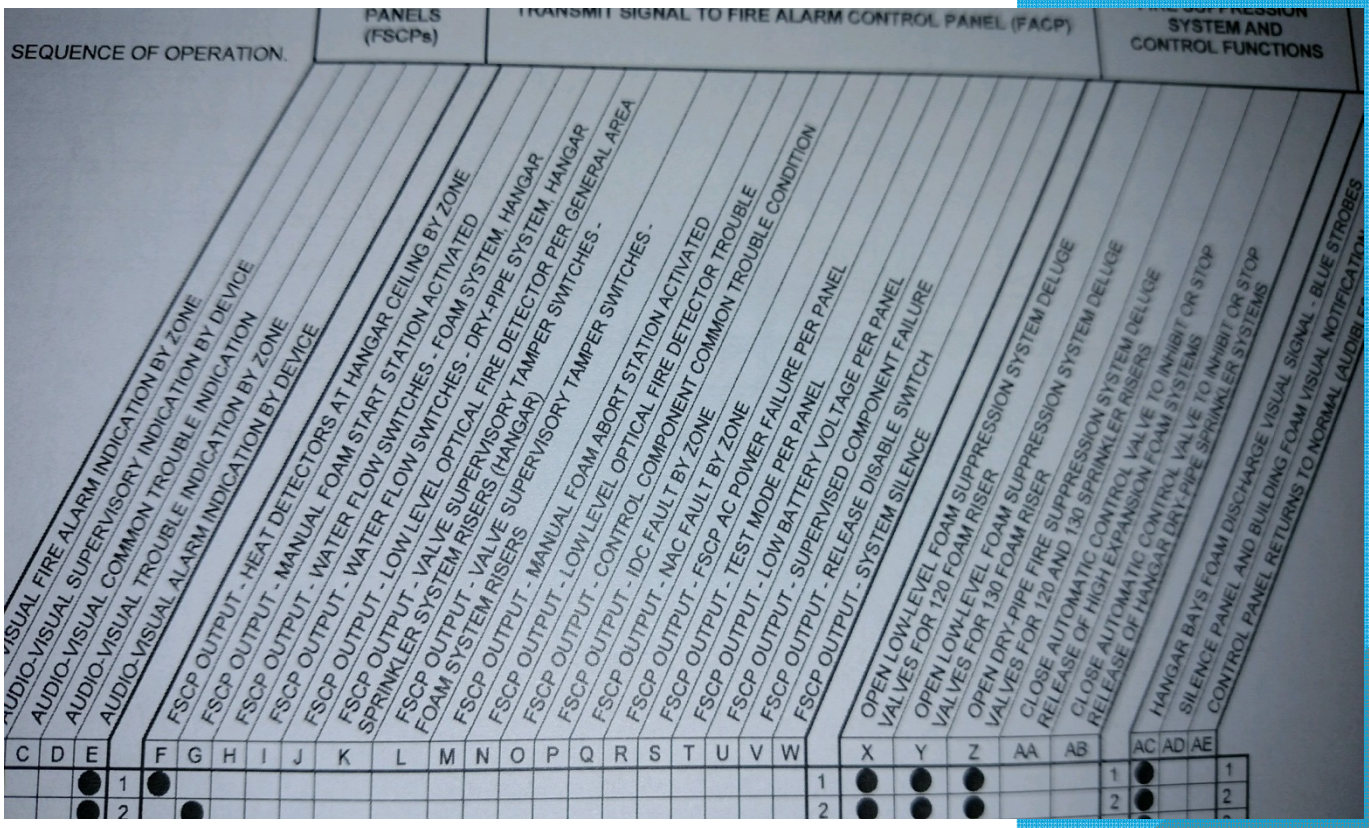
19	NOTIFICATION APPLIANCE CIRCUIT SHORT
20	NOTIFICATION APPLIANCE CIRCUIT GROUND
21	AC POWER FAILURE
22	TEST MODE
23	FSCP LOW BATTERY VOLTAGE
24	SUPERVISED COMPONENT FAILURE
	PANEL FUNCTIONS
25	FSCP RELEASE DISABLE SWITCH
26	SYSTEM SILENCE
27	SYSTEM RESET


SEQUENCE OF OPERATION.
PANELS (FSCPs)
TRANSMIT SIGNAL TO FIRE ALARM CONTROL PANEL (FACP)
SYSTEM AND CONTROL FUNCTIONS
AUDIO-VISUAL FIRE ALARM INDICATION BY ZONE
AUDIO-VISUAL SUPERVISORY INDICATION BY DEVICE
AUDIO-VISUAL COMMON TROUBLE INDICATION
AUDIO-VISUAL TROUBLE INDICATION BY ZONE
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FSCP OUTPUT - HEAT DETECTORS AT HANGAR CEILING BY ZONE
FSCP OUTPUT - MANUAL FOAM START STATION ACTIVATED
FSCP OUTPUT - WATER FLOW SWITCHES - FOAM SYSTEM, HANGAR
FSCP OUTPUT - LOW LEVEL SWITCHES - DRY-PIPE SYSTEM, HANGAR
SPRINKLER SYSTEM RISERS (HANGAR)
FSCP OUTPUT - VALVE SUPERVISORY TAMPER SWITCHES - FOAM SYSTEM RISERS
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SILENCE PANEL AND BUILDING FOAM VISUAL NOTIFICATIO
CONTROL PANEL RETURNS TO NORMAL (AUDIBL
C D E F G H I J K L M N O P Q R S T U V W X Y Z AA AB AC AD AE
1 2

Testing and Acceptance
PAT and FAT

GSAB Hangar
Ft. Carson, Colorado
21 13 20.00 20-1
July 7, 2015

The following is a Checklist or Guideline the TCX uses for Preliminary Acceptance Testing (PAT) and Final Acceptance Testing (FAT). There are likely items that will not apply to this project; likewise, there are likely items necessary for this project that are not on the list. Please utilize the document as a guideline to understand the depth of testing expected by the TCX.

Preliminary Acceptance Test (PAT) and Final Acceptance Test (FAT) Check List
(edited March 19, 2014)

1. This is a check list to be used prior to commencing preliminary and final acceptance tests.
2. The intent is to stream line the preliminary and final acceptance testing procedures and to accomplish a successful and quality acceptance test. The items (comments) are based on lessons learned and best engineering judgment.
3. This document may be used as a check list and in assigning action items to the subcontractors by the CQC manager.
4. Discuss the testing procedure with the Base Fire Marshal and Base Civil Engineer and obtain approval.
5. Provide test procedures for each specification section separately.
6. Provide a list of tests to be performed for each specification section.
7. Provide a test plan for each day of the test such as Day 1, Day 2, etc.
8. Allocate adequate time for each test. Please note that 100% testing will be done during PAT and FAT. FAT is a complete repeat of the PAT except for hydrostatic tests, flushing, and megger tests. The complete FAT will be witnessed by the TCX representative. Simultaneously conducting more than one test is not permitted. Please do not mix training with testing.

Testing and Acceptance

ECB 2015-17

Final Tests – *"Perform pan fire acceptance tests, using the expected aircraft fuel, at multiple locations on the hangar floor, including at least one at each designated aircraft parking spots to demonstrate coverage by at least three optical flame detectors. Use a 2' x 2' (or smaller) test pan. Three detectors are required to activate within 20 seconds."*

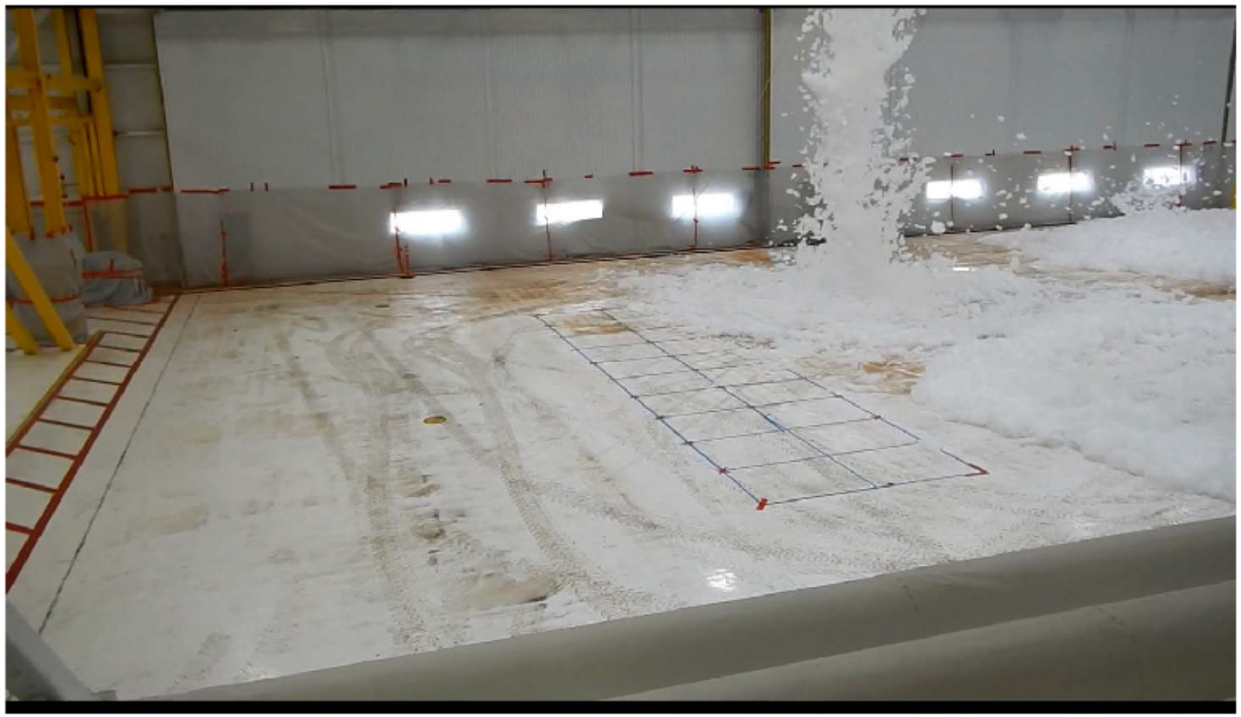
Videos – Sample Tests

Who Accepts – AHJ – DoD

AHJ for DoD is USACE Technical Center of Expertise (TCX) Middle East District and then Contracting Officer (COR)

Failed Preliminary Test

Requirement: Cover 90% of Silhouette within 1 minute
Results of Retest: Photo Taken at 1 Minute/10% Covered. Failed



Past Problems - Mishaps

De-icer Truck in Hangar – Bagram AFB 12/22/2015

Marine reportedly filled Japan Air Force hangar with foam
June 16, 2015

King Hangar at Eglin, AFB
January 10, 2014
One Person Dies

References:

NFPA 11 Standard for Low-, Medium-, and High-Expansion Foam
NFPA 11A Standard for Medium- and High-Expansion Foam Systems
NFPA 409 Standard on Aircraft Hangars

AF ETL 02-15 Engineering Technical Letter: Fire Protection Engineering Criteria – New Aircraft Facilities
AF Criteria Changes – 10 March 2016 (similar to ECB 2015-17)

ECB 2015-17 Engineering and Construction Bulletin – Changes to Reduce False Activations of High Expansion Foam Systems in Army Hangars

UFC 3-600-01 - Fire Protection Engineering for Facilities
UFC 4-211-01 – Aircraft Maintenance Hangars
UFC 4-211-02 – Aircraft Corrosion Control and Paint Facilities

http://www.chemguard.com/about-us/documents-library/design-manual.htm

Questions?