Fire and Life Safety Analysis

AF Child Development Center (CDC) Standard Design

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Integrity - Service - Excellence

Presentation Outline

- **Building Layout**
- **Code Analysis**
- **Egress Analysis**
- **Fire Detection and Alarm Systems**
- **Fire Suppression System**
- **Performance Based Analysis**
- **Recommendations**

Building Layout

53 CDCs BUILT AF WIDE
TOTAL FLOOR AREA
BUILDING HEIGHT
1 STORY

2009-CURRENT
37,890 SF
24FT

Building Layout

APPLICABLE CODES AND STANDARDS

UFC 1-200-01, *GENERAL BUILDING REQUIREMENTS*

UFC 3-600-01, *DESIGN: FIRE PROTECTION ENGINEERING FOR FACILITIES*

NFPA 101, *LIFE SAFETY CODE* - 2009 EDITION

IBC -2009 EDITION

Building Layout-Site Plan

- EVACUATION PATHS
- PUBLIC WAY
- EMERGENCY VEHICLE ACCESS

Building Layout-Interior

- **REMOVED FOR SECURITY REASONS**

Code Analysis

Used in the following order for AF Installation:

- **UFC 1-200-01, *General Building Requirements***
- **Engineering Technical Letters (ETL)**
- **IBC or UFC 3-600-01, *Design: Fire Protection Engineering For Facilities***
- **NFPA 101**
 - **All other codes and standards are referenced from one of the above.**

Code Analysis

- **UFC 1-200-01, *General Building Requirements***
 - **1-2.1: All references of IFC in IBC shall be considered references to NFPA 1**
 - **IBC chapters and parts of chapters substituted with Military Criteria UFC's.**

USE IBC Chapters					Do NOT Use IBC Chapters
1	12*	19*	25	31	4
2	14	20	26	32	8
3	15	21*	27*	33	9
5	16*	22	28*	34*	10
6	17*	23	29*	35*	11
7	18*	24	30*		13

*** Indicates chapter used as modified in UFC 3-600-01 and other UFCs**

Code Analysis

Day Care Occupancy (NFPA 101, 3.3.188.4)-Group I-4 (IBC)

An occupancy in which four or more clients receive care, maintenance, and supervision, by other than their relatives or legal guardians, for less than 24 hours per day.

Construction Type IIB (IBC)

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A ^d	B	A ^d	B	HT	A ^d	B
Primary structural frame ^g (see Section 202)	3 ^a	2 ^a	1	0	1	0	HT	1	0
Bearing walls									
Exterior ^{f, g}	3	2	1	0	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions	See Table 602								
Exterior									
Nonbearing walls and partitions									
Interior ^e	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and secondary members (see Section 202)	1½ ^b	1 ^{b, c}	1 ^{b, c}	0 ^c	1 ^{b, c}	0	HT	1 ^{b, c}	0

Code Analysis

Fire Resistance Rating Requirements

<u>Occupancy Separation</u>	<u>Fire Resistance Rating</u>
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Laundry room	1 hour
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- Per UFC 4-740-14, *Design: Child Development Centers*, the only fire barriers required in the facility is the a one hour fire resistive barrier around the laundry room.
- Per Standard Design, walls extend to the roof deck.

Code Analysis

**The Life Safety Code staff-to-child ratios
(NFPA 101, A.16.1.1):**

1 to 3: $\leq$ 24 months

1 to 4: $\leq$ 36 months

1 to 7: $\leq$ 60 months

The DoD staff-to-child ratios (AFI 34-248):

1 to 4: $\leq$ 12 months (Infant)

1 to 5: $\leq$ 24 months (Pre-Toddler)

1 to 7: $\leq$ 36 months (Toddler)

1 to 12: $\leq$ 60 months (PreSchool)

Code Analysis

New Staff Ratios=Compensatory Measures

NFPA 101, 2009 edition, A.16.1.1):

“If staff-to-client ratios fall below that suggested by Table A.16.1.1, it is the responsibility of the authority having jurisdiction to determine the additional safeguards beyond the requirements of Chapter 16 that are necessary. Typical additional provisions might include restricting the day-care occupancy to the level of exit discharge, requiring automatic sprinkler protection, requiring better or additional means of egress, and similar types of provisions, depending on the situation.”

Code Analysis

UFC 4-740-14
1 August 2002

UNIFIED FACILITIES CRITERIA (UFC)

DESIGN:
CHILD DEVELOPMENT CENTERS

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

UFC 4-740-14, *Design: Child Development Centers* criteria established in 1992 and adopted by all of DoD in 2002 when UFC was published

Code Analysis

- **Must be single story; with all egress on level of exit discharge**
- **No Dead Ends Permitted (of any length)**
- **All child activity rooms (CAR) required to have doors to outside**
 - **must be 36” wide**
 - **Must provide 34” clear width**
 - **Full-width, flush type panic hardware**
 - **Means for immediate reentry**
 - **Hold-open device built into closer**
 - **Fire alarm manual pull station adjacent to door**
- **Corridors required to be between 6.5 and 8 feet wide**

Code Analysis

- **Complete automatic wet pipe sprinkler protection required – quick-response listed sprinkler heads; use UFC design criteria**
- **Complete smoke detection required – in all spaces over 20 ft² except kitchen and spaces not climate controlled as defined in NFPA 72**
- **Fire Alarm Signal to be chime sound**
- **Kitchen – provide magnetic hold-open on door to corridor**
- **All return air must be ducted back to the unit**

Code Analysis

- **Emergency lighting per NFPA 101 - plus lighting in each child occupied activity room (near center) and over front desk**
- **Electrical receptacles in child occupied areas must be tamper-resistant (TR- listed) and mounted NLT 54 inches above finished floor**
- **2011 NEC-All electrical receptacles in CDCs must be TR**
- **Smooth, paved surface from all outside doors and corridor exit doors to safe gathering area(s) at least 75 feet from the building**

Egress Analysis

Occupant Load < Egress Capacity = OK

		AF Max OL per classroom + 2 Caregivers									
	OL FactorPer NFPA 101	< 12 M	12-24M	24-36M	3-5 Yrs	Total sq. ft.	Total OL	Door Width (in)	Egress Capacity Factor	# Doors	Egress Capacity
Day Care	35	8	10	14	24	16837	482	34	0.2	21	3570
# of classrooms		5	5	6	5						
Child Total		40	50	84	120						
Total + Caregivers		50	60	96	130		336				
Corridor								78	0.2	10	3900
Training/break	15					919	62	32	0.2		
Business	100					2249	23	32	0.2		
Kitchens	100					1194	12	32	0.2		
Laundry	100					237	3	32	0.2		
Storage	300					2680	9	32	0.2		
Mechanical	300					1927	7	32	0.2		
Total OL NFPA 101							598				
Total OL AF Ratio							452				
Total Egress Capacity											5170

Egress Analysis

TRAVEL DISTANCE < 100 FT

- EXIT DOORS
- doors from CARs are "doors to the outside"
 - All corridor exit doors require exit signs- doors from CARs do not
- Common Path of Travel < 100ft

Fire Detection and Alarm Systems

Combination, Addressable, Class B Fire Alarm/Mass Notification System (MNS)

- **UFC 3-600-01, *Design: Fire Protection Engineering For Facilities***
- **UFC 4-740-14, *Design: Child Development Centers***
- **UFC 4-021-01, *Design And O&M: Mass Notification Systems***
- **NFPA 72, *National Fire Alarm and Signaling Code***

- Alarm signal transmits directly to fire dispatch
- Alarm notification via speakers and synchronized strobes
- Temporal 3 signal, then female voice evacuation
- Live voice capability to override pre-recorded messages
 - Sends supervisory signal to fire dispatch

- Manual pull station at every exit door and CAR doors to outside
- Smoke detection in all areas greater than 20 sq. ft. except kitchen and spaces not climate controlled
- Magnetic hold open on kitchen door
- Duct smoke detection IAW NFPA 90A
- HVAC shutdown IAW UFC 4-010-01, *DoD Minimum Antiterrorism Standards For Buildings*

Fire Detection and Alarm Systems

- **MNS strobes are required in all areas fire alarm strobes required**
- **MNS strobes required to be marked with word “alert” on device and are amber**
- **Speakers installed in all spaces to obtain required intelligibility of voice signals of 0.8 Common Intelligibility Scale (CIS)**

Fire Detection and Alarm Systems

FIRE ALARM/MNS OPERATIONS MATRIX		REQUIRED SYSTEM OUTPUTS													
		ANNUNCIATION/INDICATION							OFF PREMISES SIGNAL TRANSMISSION				ANCILLARY FUNCTIONS		
SYSTEM INPUTS	<div>ACTUATE ALARM AND VIBRA. FIRE ALARM NOTIFICATION APLA, WCHS RETURNED</div> <div>ACTUATE ALARM AND VIBRA. FIRE ALARM NOTIFICATION APLA, WCHS INDICATION AT FACU</div> <div>ACTUATE ALARM AND VIBRA. FIRE ALARM NOTIFICATION APLA, WCHS SUPERVISORY INDICATION AT FACU</div> <div>ACTUATE ALARM AND VIBRA. FIRE ALARM NOTIFICATION APLA, WCHS SUPERVISORY INDICATION AT FACU</div> <div>PROVIDE DISCONNECT INDICATION AT FACU</div> <div>INTERMITTENT OPERATOR OF ALARMS FIRE ALARM NOTIFICATION APLA, WCHS BRICKER CIRCUITS</div> <div>PROVIDE ALARM SIGNAL TO FIRE DEPARTMENT ALARM RECEIVING STATION</div> <div>SWARM ALARM SIGNAL TO FIRE DEPARTMENT ALARM RECEIVING STATION</div> <div>TRANSMIT TROUBLE SIGNAL TO FIRE DEPARTMENT ALARM RECEIVING STATION</div> <div>TRANSMIT TROUBLE SIGNAL TO FIRE DEPARTMENT ALARM RECEIVING STATION</div> <div>SHUT DOWN AFFECTED AIR HANDLING IN HVAC SYSTEM</div> <div>CLOSE FIRE AND SMOKE DAMPERS IN HVAC SYSTEM</div> <div>RELEASE MANNED DOOR HOLDERS ON FIDLER DOORS</div>														
	ALARM SIGNALS														
MANUAL FIRE ALARM BOX	●		●			●				●					●
SPRINKLER WATERFLOW	●		●			●				●					●
MASS NOTIFICATION SYSTEM INPUT OR ACTUATION OF LOCAL MICROPHONE		●					●	●			●				
KITCHEN FIRE SUPPRESSION SYSTEM ACTUATION	●		●			●				●					●
SMOKE DETECTOR ACTUATION	●		●			●				●					●
CARBON MONOXIDE DETECTOR ACTUATION (SEE NOTE 2)		●				●				●					
DUCT SMOKE DETECTOR	●		●			●				●			●	●	●
SUPERVISORY SIGNALS															
VALVE SUPERVISORY SWITCH				●		●				●					
TROUBLE SIGNAL FROM KITCHEN SUPPRESSION SYSTEM				●		●				●					
TROUBLE SIGNALS															
OPEN CIRCUIT (SEE NOTE 1)					●					●					
CIRCUIT GROUND FAULT (SEE NOTE 1)					●					●					
AC POWER FAILURE (SEE NOTE 1)					●					●				●	

Carbon Monoxide Detection

- Detection system installed IAW NFPA 720 if natural gas installed in bldg.
- Locate on ceiling of room where there are permanently installed fuel burning appliances and a least one detector centrally located in each HVAC zone

Fire Suppression Systems

Complete Automatic Wet Pipe Sprinkler Protection

- quick response sprinkler heads
- schedule 40 piping
- criteria IAW UFC 3-600-01 & NFPA 13

Sprinkler System and Water Supply Design Requirements for Sprinklered Facilities

OCCUPANCY CLASSIFICATION ^a	SPRINKLER SYSTEM		HOSE STREAM ALLOWANCE L/Min (GPM)	DURATION OF SUPPLY Minutes
	DESIGN DENSITY L/min/m ² (GPM/ft ²)	DESIGN AREA m ² (ft ²)		
Light Hazard	4.1 (0.10)	280 ^b (3000) ^b	950 (250)	60
Ordinary Hazard Group 1	6.1 (0.15)	280 ^b (3000) ^b	1900 (500)	60
Ordinary Hazard Group 2	8.2 (0.20)	280 ^b (3000) ^b	1900 (500)	90
Extra Hazard Group 1	12.2 (0.30)	280 (3000)	2840 (750)	120
Extra Hazard Group 2	16.3 (0.40)	280 (3000)	2840 (750)	120

NFPA 13, 11.2.3.2.3
*ceilings <10 feet 40% reduction: 3000 sq ft-1200 sq ft= 1800 sq ft design area

Fire Suppression Systems

- Cross mains: 4"
- Branch lines 1-1.5"

Static Pressure:	52 PSI
Residual Pressure:	50 PSI
Flow	900 GPM

Total Water Demand:	604 GPM
PSI:	44.9

Fire Suppression Systems

Additional Fire Suppression

- A wet chemical fire suppression system is installed in kitchen IAW NFPA 17A & NFPA 96
- Class K fire extinguisher in kitchen
 - No other fire extinguishers in facility

Performance Based Analysis

Design Fire Scenarios

Goal: Life Safety-determine if the ASET > RSET with margin of safety base on assumed fire: AF required EVAC time is under 2 min.

Scenario	Location	Fire Control
1	Laundry room	Sprinklers/Rated Construction
2	Laundry room	Sprinklers/door open
3	Laundry room with & without smoke detection

Performance Based Analysis

Tenability Criteria		
Design Criteria	Tenability Limit	Justification
Visibility Limit	<13 feet (4 meters)	Jin, SFPE Handbook, Table 2-4.2. Assume building occupants are familiar with surroundings.
Temperature Limit	<140°F (60°C) @ 4.9 ft. (1.5m) AFF	NFPA HB, section 6, chpt 2 (teachers and children are not expected to be able to enter the corridor from a relatively cool classroom at temperatures above this)
Carbon Monoxide	<1400 ppm	SFPE HB section 2, chpt 6, Table 2-6.B1. The CO incapacitation levels from exposure for 30 minutes is between 1400-1700 ppm. The goal in the CDC would be to stay below the levels of incapacitation.

Performance Based Analysis

ASET > RSET

ASET (Available Safe Egress Time): time from ignition until bldg./room becomes untenable

RSET (Required Safe Egress Time): time needed by occupants to evacuate from the bldg./room

Pathfinder Travel Time (sec)
20.8

Hand Calculated Travel Time (sec)
24

Performance Based Analysis

RSET = 138 seconds ($t_d + t_a + t_o + t_i + t_e$) SFPE HDBK Sec 4, Chpt 13

- t_d = detection time
- t_a = notification time
- t_o = pre-movement time
- t_i = action time
- t_e = travel time

Detection and Notification Time, $t_d + t_a$ (sec)	Pre-movement and Action Time, $t_o + t_i$ (sec)	Travel Time, t_e (sec)	RSET Total Time (sec)	1.5 times RSET Safety Factor (sec)
8	60	24	92	138

$t_d + t_a$ = visual awareness, smoke detectors, sprinklers, or manual alarm

$t_o + t_i$ = Control area with CCTV, well trained staff

t_e = hydraulic model of emergency egress from SFPE Handbook

Performance Based Analysis

FDS Modeling Floor Plan

Performance Based Analysis

Tumble Dryer – Heat Release

- Fire based on experimental data
- The European Flame Retardant Association (EFRA) sponsored a series of fire tests of household appliances

Performance Based Analysis

Laundry Room with Doors Closed

Performance Based Analysis

Laundry Room with Doors Open

Performance Based Analysis

Laundry Room Door Closed

Visibility at 330 s $\approx$ 4m

Temperature at 330 s $\approx$ 20°C

CO Level at 330 s $\approx$ 0 ppm

Performance Based Analysis

Visibility at 140 s $\approx$ 4m

Laundry Room Door Open

Temperature at 140 s $\approx$ 20°C

CO Level at 140 s $\approx$ 0 ppm

Recommendations

- **Additional funding to further develop FDS software**
- **Encourage Standard Design criteria to be implemented into UFC documents**
- **Propose smoke detection in all spaces greater than 20 sq. feet in NFPA 101**
- **NFPA 101 proposal to provide doors directly to the outside in all CARs**
- **All CAR doors leading to the corridor should be self closing**

Questions?