FIRE SAFETY MODELING OF OFFSHORE PETROLEUM FACILITIES PLATFORM

by

Mohamed Abdelgadir Mohamed Ahmed Elfaki
15800

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Mechanical)

AUGUST 2014

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHAMED ABDELGADIR M.AHMED ELFAKI

CERTIFICATION OF APPROVAL

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ABSTRACT

Fire event is a major area of concern especially in the presence of large quantities of hydrocarbons just as in the case of an offshore platform. Thermal radiation is found to be the primary mechanism for causing hazards to individuals, assets and environment as a result of a fire event in open areas. This project aims to assess the fire safety system of an offshore petroleum facility in order to allocate the most beneficial and safest evacuation egress using CFD-FDS software. This should be accomplished by investigating the effect of the produced thermal radiation during the worst case scenario within the offshore petroleum facility platform. Moreover, the researcher will highlight system deficiency and propose recommendation for future facilities layout design (e.g. installation of equipment). The researcher has successfully developed the full-scale model of the offshore platform under investigation. Two mesh sizes were used to measure the evacuation time for the whole facility and found is 248 seconds and 191 seconds for fine and coarse mesh respectively. The produced thermal radiation is vary along the evacuation routes. Preventive measurements should be taken in the locations that detected high incident heat flux which can lead to equipment and human loss. Ground deck is found to be safe except in the location with coordinates of x=15.0, y=15.0, z=6.0 in which a number of 71 occupants will be exposed to 300°C. Upper deck are safe and temperature trends vary in normal range. Thermal resistance wall should be installed in the hazard location for human and property prevention.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Fire event is a major area of concern especially in the presence of large quantities of hydrocarbons just as in the case of an offshore platform. Generally, ignition of hydrocarbons or any combustible fuel in the industrial facilities can produce different types of fires such as pool fires, jet flames, vapor cloud fires or fireballs depending on the condition of release and ignition of that particular fuel. In fact, each of these fire types' exhibit different characteristics but they tend to share a similar mechanism of impact.

Thermal radiation is found to be the primary mechanism for causing hazards to individuals, assets and environment as a result of a fire event. Potential outcomes due to thermal radiation is either immediate, if anyone exposed to the radiant flux, or delayed and lastly will lead to a devastating event (Rew et al., 1997). Obviously, severity degree of the thermal radiation incident on a body is varying from each type of fires due to the different characteristics. Humans' injury and damage or even loss of the multi-billion structure as a result of a thermal radiation impingements are serious consequences. Human skin exposure duration for the radiant heat flux generated from the fire has a significant measurement for the severity. Severity level is varying with type of fire, distance between the source and target, intensity of the generated thermal radiation and many other factors (Palacios et al., 2012). In addition, most frequently in an offshore platform a primary fire event can cause explosion of adjacent equipment which containing a combustible fuel and thus a secondary fire event will occur.

Moreover, smoke and toxic combustion products which produced by fire and tend to restrain individual's visibility and hence lessen their possibility to survive should be viewed (Benucci & Uguccioni, 2011). Hence, and for the above-mentioned findings, efforts should be taken seriously toward the fire safety modeling of offshore platforms prior construction and in parallel with the designing process. This will predict the effects of the presented potential hazardous in the platform and hence will allow for further precautions during the design process. Predicting fire, smoke and thermal radiation behavior will allow for safe layout design and evacuation route which will prevent loss of individuals' life and cost of these multi-billion structures (Donhaiser, 1954).

In fact and most frequently, oil and gas operating companies depend on safety standard codes for fire protection within their facilities which considered perspective in nature. However, depending on the presence of the potential hazardous elements there should be a specific fire protection system demand the situation. Hence, identifying the most appropriate fire protection system and finally evaluate the situation using the performance-based design criterion by advanced fire assessment software is essential. Computational Fluid Dynamic (CFD), Fire Dynamic Simulator (FDS), Smokeview (SMK) and Evacuation (EVAC) are considered the advanced techniques which can be used for the fire safety modeling rather than using analytical assessment techniques. Each one of these soft-wares designed for a specific scope in the fire modeling.

Applying the CFD, FDS, SMK or EVAC soft-wares will allow to simulate the system with typical conditions that close to the reality which found within our offshore system. It is found more efficient and reliable rather than the analytical assessment methods. Thus, more accurate results which can predict clearly the fire event development process, smoke behavior during fire, temperature profile reached by each of the exposed components to the fire and many other findings which in turns will allow to efficiently design and install of the offshore facility. In addition, of course, this will cut down the invested cost for the installed passive or active protection systems, assure occupants safety and company's assets and properties.

1.2 PROBLEM STATEMENT

Fire event is a major consideration especially in the field of oil and gas industry as it might cause serious devastating accidents. Due to a serious fire incident scenario, severe injury or even death of the platform’s occupants, due to thermal radiation impingement, might occur depending on the particular fire type, intensity of the heat flux, distance between the source and target and many other factors. Moreover, loss or damage of the multi-billion dollar structure can be triggered.

Hence, potential consequences due to the generated thermal radiation, smoke and toxic combustion products due to fire can be crucial. Hence, determining the behavior of the generated thermal radiation and smoke with aid of computer simulation software (e.g. CFD-FDS) is recommended, rather than analytical assessment methods, in order to identify the safest evacuation egress by assuming the worst case scenario of a fire event. Since nowadays designers are relying more on the analytical assessment without considering the advanced computer techniques to simulate the typical condition of the reality. This is to assure suppression of fire expansion and safe evacuation routes which eventually lead to minimize the required time for evacuation in fire event.

1.3 OBJECTIVES

- To assess fire safety system of an offshore petroleum facility and allocate of the safest evacuation egress and time using CFD-FDS software.
- To investigate the effect of the produced thermal radiation during a fire event within the offshore platform.
- To compare the obtained results from the developed CFD-FDS model with the optimum evacuation egress of offshore petroleum facilities common standard in oil and gas industry.
- To highlight system deficiency and propose recommendation to improve the current fire safety system.

1.4 SCOPE OF STUDY

This project aims to model a fire event in an offshore platform by using CFD-FDS Software. This will allow to evaluate the fire safety design of the offshore facility and determine the safest evacuation egress which is not affect by fire detrimental effects (e.g.

produced thermal radiation). In addition, it will allow to highlight the system deficiency and provide recommendations for future fire safety designing and installation of any offshore petroleum facility equipment (layout). This is typically an implementation of the performance-based design principle which is more likely rather than perspective-based design (analytical assessment). The researcher shall cover both assessment techniques and compare between both results accuracy.

1.5 FEASIBILITY OF THE PROJECT

The researcher has established the plan to accomplish the project within its time constraint during FYP (1) and FYP (2). For the first period of the project (FYP 1), the researcher plans to get the basic knowledge of the firefighting engineering and to be familiarized with the simulation software CFD-FDS. Moreover, the researcher plans to develop the preliminary model using the software in order to check the model and run the simulation. Afterwards, developing the fully-scaled model during the second period of the project (FYP 2) will be accomplished. Then, the researcher will analyze the results and findings to determine the safest evacuation egress and timing for the offshore facility.

The two semesters are expected to enable the researcher to complete the project within its time constraints. Project Gantt chart (chapter three – Figure 3-1) can provide a clear view of the project timeframe.

CHAPTER TWO

LITERATURE REVIEW

Fire event in the oil and gas industry leads to a devastating accident as it might cause serious consequences. Individual's life loss and damage of the multi-billion structure (e.g. offshore platform) can be triggered. Beyler (2002) reported that several forms of fires due to the hydrocarbon fuels ignition can be produced in the industrial facilities (e.g. offshore platform) such as pool fires, jet flames, vapor cloud and fireballs. Potentially hazardous result from a fire event is the produced thermal radiation and heat flux.

It is very useful to evaluate the produced thermal radiation in case of fire by using either analytical methods or advanced computerized soft-wares. This is to determine the safest and fastest evacuation egress that is not affected by the effects of fire (Tan , 2011).

2.1 THERMAL RADIATION EFFECTS

Several researches (Rew et al., 1997;Beyler, 2002) found that the primary mechanism of impact in case of large-open fire event is due to the thermal radiation. Severity of the thermal radiation depends on the its intensity and incident heat flux on the target. Also its found that propagation of the thermal radiation with adjacent equipments which contain combustible fuels can occur and then will cause further fire events (Satoh, et al., 2011; Palacios et al., 2012). This is called the domino effect and its found that out of 225 fire accidents occured that 36% found as a result of another fire propagation.

Human exposure of this thermal radiation is a major issue. Severity due to this exposure depends on duration of exposure, intensity of the thermal radiation strike the skin and type of clothing. Benucci and Uguccioni (2011) stated that incapacitation and death due to hyperthermia as a result from the thermal radiation exposure can occurred. In addition, due to body incapacitation this will result to drastically loss his fluid contents which in turns will lead to fall in blood pressure and even loss of consciousness.

Also, skin burn injury due to the thermal radiation is most frequently found during fire event. Skin burns is divided into three subcategories (First degree, Second degree and Third degree) and its found that when skin surface temparature reaches 55°C blistering will occur. In addition Beyler (2002) cited that time to cause pain for human is depend on the incident flux as per figure (2-1) and (2-2) below.

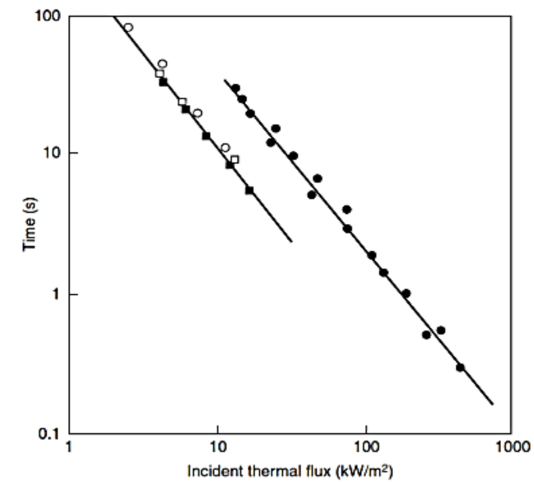


Figure 2-1: Time required for skin burns by thermal radiation. (Beyler, 2002)

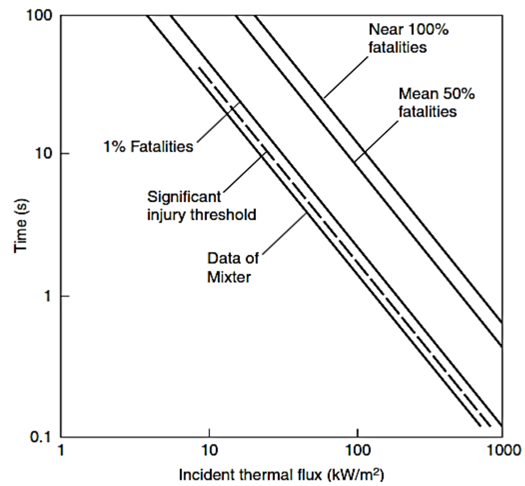


Figure 2-2: Fatality levels for thermal radiation. (Beyler, 2002)

Obviously, estimating the level of injuries could be determined for the specified produced radiant flux from a particular fire event. Hence, this will allow designers to develop an evacuation egress that satisfy all evacuees to escape without hardly exposing to the produced critical radiant flux. That is why it is recommended to build the living area on an offshore platform in considerable distance from the operating zone (Donhaiser, 1954).

2.2 EVACUATION EGRESS AND TIMING

Assuring a safe evacuation egress for individuals should be practised before the construction and in parallel with the design process of any platform facility. It is clearly known that any evacuation egress must lay down far away from any source of ignition (e.g combustible fuels) and any high hazard areas. Using one of either advanced computer techniques or analytical assessment to predict the behaviour of a fire event is very significant to determine the safest evacuation egress and timing (Tan et al., 2012). Usually by predicting the worst case seniro of a fire event for a particular design layout should be done in order to determine the optimal design.

As mentioned-above, several techniques allow to determine the most suitable evacuation egress and timing which are advanced computer techniques and analytical assessment. The latter is found to have very serious limitation in order to obtain the optimal results (Shih et al., 2000). Therefore, using of the advanced computer techniques to simulate the worst case scenario and applying the performance-based design criterion is preferable. On the other hand, analytical assessment methods are preferable for the simple scenarios. In fact, the designer should assume by his own the evacuation egress for occupants which in turns could be determined by the advanced techniques. Moreover, taking into account the human behaviour and individual perception can only be assessed by the advanced computer techniques.

Fire modeling for assessing the particular design can be accomplished by using Fire Dynamic Simulator-Evacuation (CFD-FDS), Simulex, EvacuatioNZ or any other relevant software. Optimal value of the evacuation timing can be attained since these advanced assessment method simulate the typical conditions of the reality and transfer it into the software.

2.4 CFD-FDS SOFTWARE

Fire Dynamic Simulator or FDS is a computational fluid dynamic (CFD) model used to analyze fire-driven fluid flow. In fact, the first software version was released early February in 2000 (Smardz , 2006). Then, software developers keep improving the software features as it now. FDS is allow to develop models for solving practical problems in fire protection and provide solutions for more safe and protected fire safety systems.

Further, modeling using CFD-FDS software is very essential as it consider a tool of the performance-based design. Computer simulation softwares (e.g. CFD-FDS) allow the engineer to establish similar conditions of the reality into the model, analyzing the model and acquire accurate results which help to the safety fire system designs. Nowadays, most of the engineers apply the principle of perspective-based design and they lack of using advanced softwares (e.g. CFD-FDS). Moreover, engineers tend to use analytical assessment for fire safety systems design through the use of equations obtained experimentally. Hence, engineer will apply the most suitable formulas obtained from almost similar conditions of that experiment. In fact, using these softwares (e.g. CFD-FDS) rather than using analytical assessment methods have many benefits which can be summarized into two points as per below:

- Applying the performance-based design principle with typical condition of reality and assuming the worst case scenario can only be accomplished using the computer softwares.
- CFD-FDS software is suitable as the complexity of system (e.g. building) and analysis increases. It allow to apply all reality conditions into the model and analyze the system to attain very high and reliable results. On the other hand, analyzing a particular systems using obtained formulas from other experiments can directly give results with low accuracy since, of course, it is not typically the same conditions of both systems (Shih et al., 2000).

Also, Engineers will be able to save cost and time. It is impractical to build a building (e.g. four stories building) and then test the building by burning it. Hence, the engineer could develop a model, using CFD-FDS software, of that particular building and apply similar conditions of the reality into the developed model.

CHAPTER THREE

METHODOLOGY

3.1 RESEARCH METHODOLOGY

The researcher has identified the steps needed to complete this project in the specified timeframe. Interpretation of the planned steps will be viewed in this section as per below:

3.1.1 Data Collection and Model Development

Through this step, the researcher aims to have the basic understanding of the fire engineering field which will allow for better interpretation and analysis for the results. In addition, learning how to simulate the particular platform layout using CFD-FDS should be accomplished to design the model and evaluate the fire safety system of the offshore platform.

3.1.2 Results Validation, Analysis and Interpretation

With aid of the basic knowledge gained and literature review resources, the researcher is capable to validate and verify the obtained results from the running simulation of the designed model. This results will allow the researcher to determine the safest and most beneficial evacuation egress of the offshore facility. Interpretation of this finding will be viewed in the discussion section.

3.1.3 Conclusion and Recommendations

Based on the findings and results interpretations, the researcher be able to highlight the system deficiency and propose recommendations.

3.2 PROJECT ACTIVITIES AND KEY MILESTONES

This project activities are based on many substrates can be shown in figure (3-1). Firstly, the researcher will attain the basic knowledge of the firefighting engineering to ease understanding and interpretation of the findings. Moreover, learn how to use and developing models using CFD-FDS software in parallel with the first step is remarkable to cut time. Afterwards, the researcher will be able to develop the preliminary model of the offshore facility platform using the software. Afterwards, the researcher will run the preliminary model simulation to check if there is any errors and correct them. Then, the author will move forward and develop the fully-scaled model of the particular offshore platform in order to obtain the preliminary results.

Afterwards, verification and validation of the obtained results is essential to assure the model is running successfully. Afterwards, the researcher will optimize the model and select a proper mesh size to obtain more accurate and adequate results. Lastly, by analyzing the attained final results, the researcher will be able to highlight fire system deficiency and set recommendations.

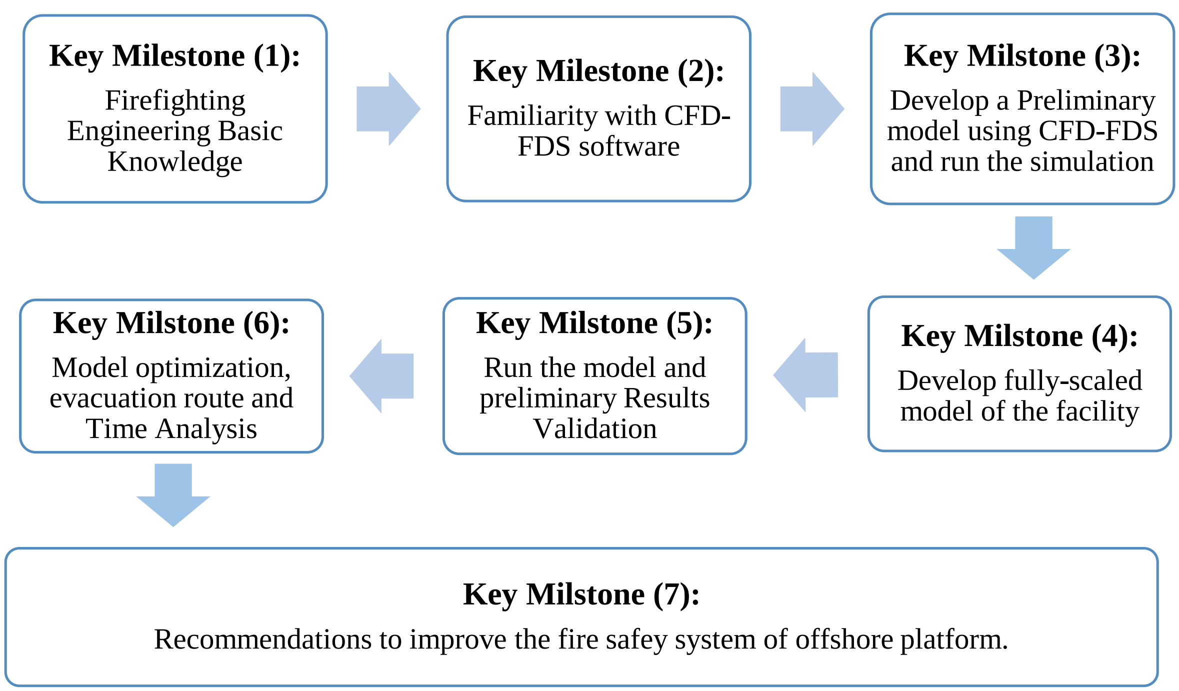


Figure 3-1: Project Key Milestones

3.3 PROCESS FLOW CHART

Figure (3-2) below, shows the process flow chart which contains a short description of the main steps for the completeness of this project.

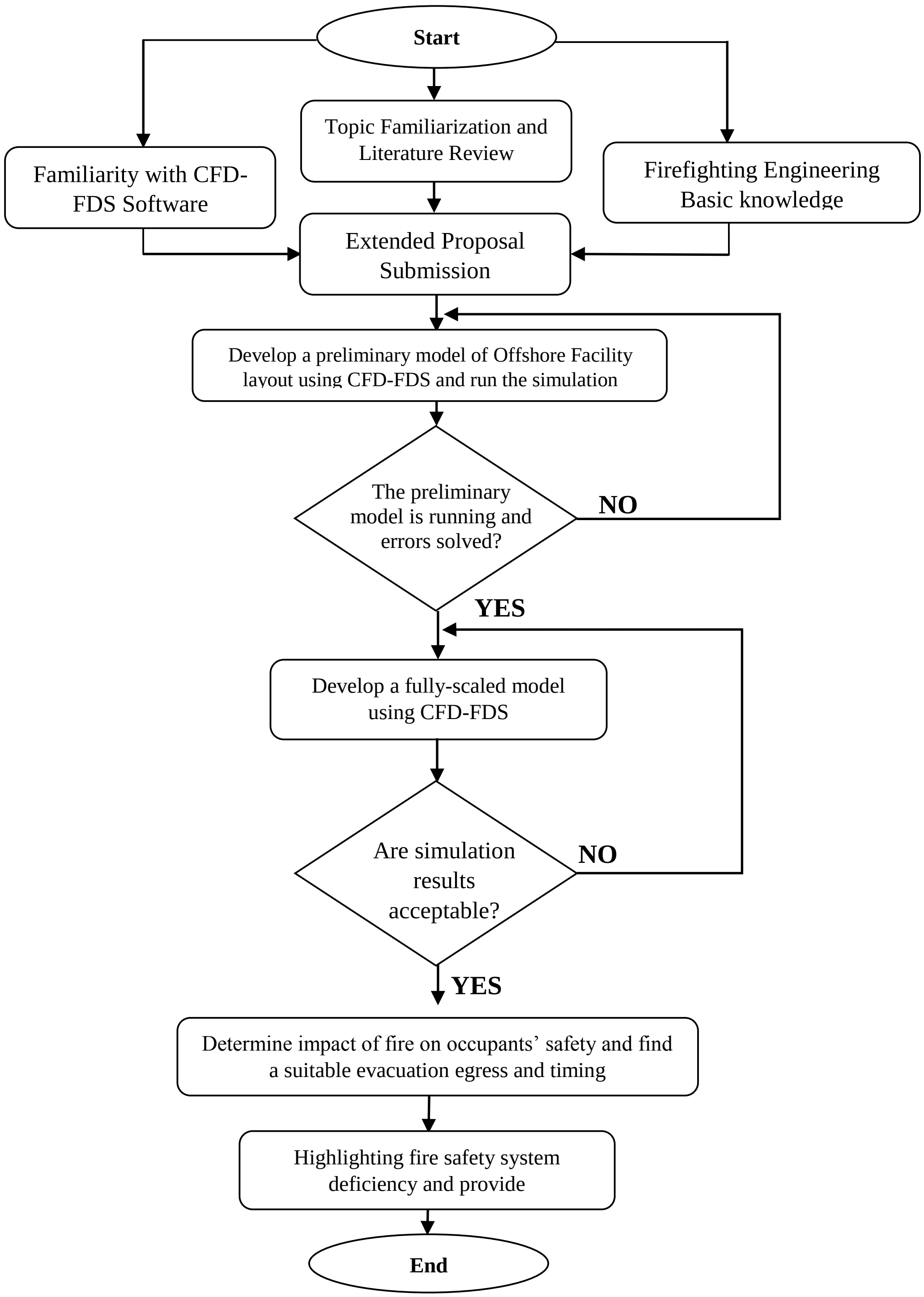


Figure 3-2: Project process flow chart

3.4 GANTT CHART

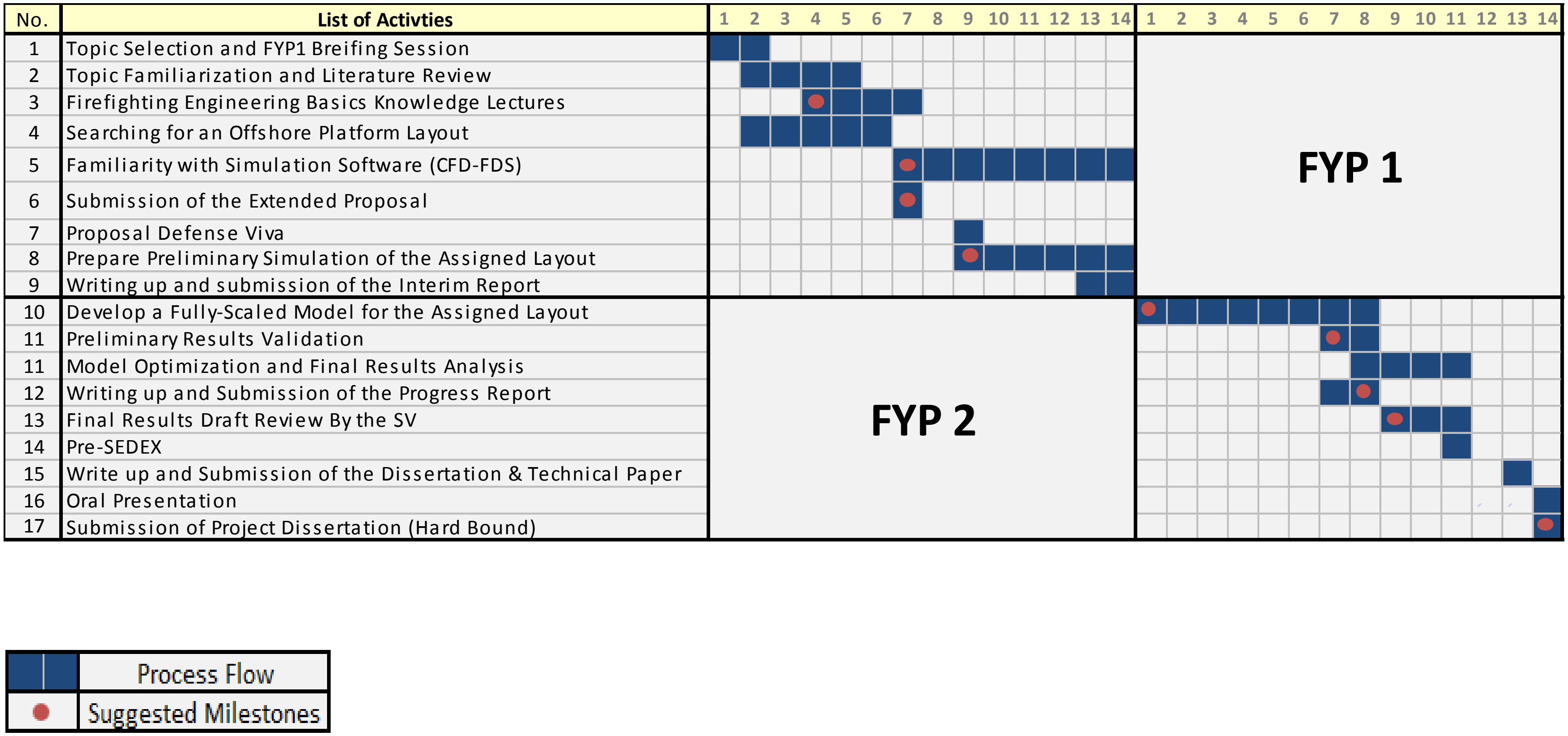


Figure 3-3: Gantt chart

CHAPTER FOUR

RESULTS & DISCUSSION

4.1 RESULTS

This project has been primarily of a simulation nature by using CFD-FDS software. The researcher was able to successfully develop the fully-scaled model of the offshore facility facility. Preliminary results have been obtained from the fully-scaled running model in order to be checked and validated to assure model is running successfully.

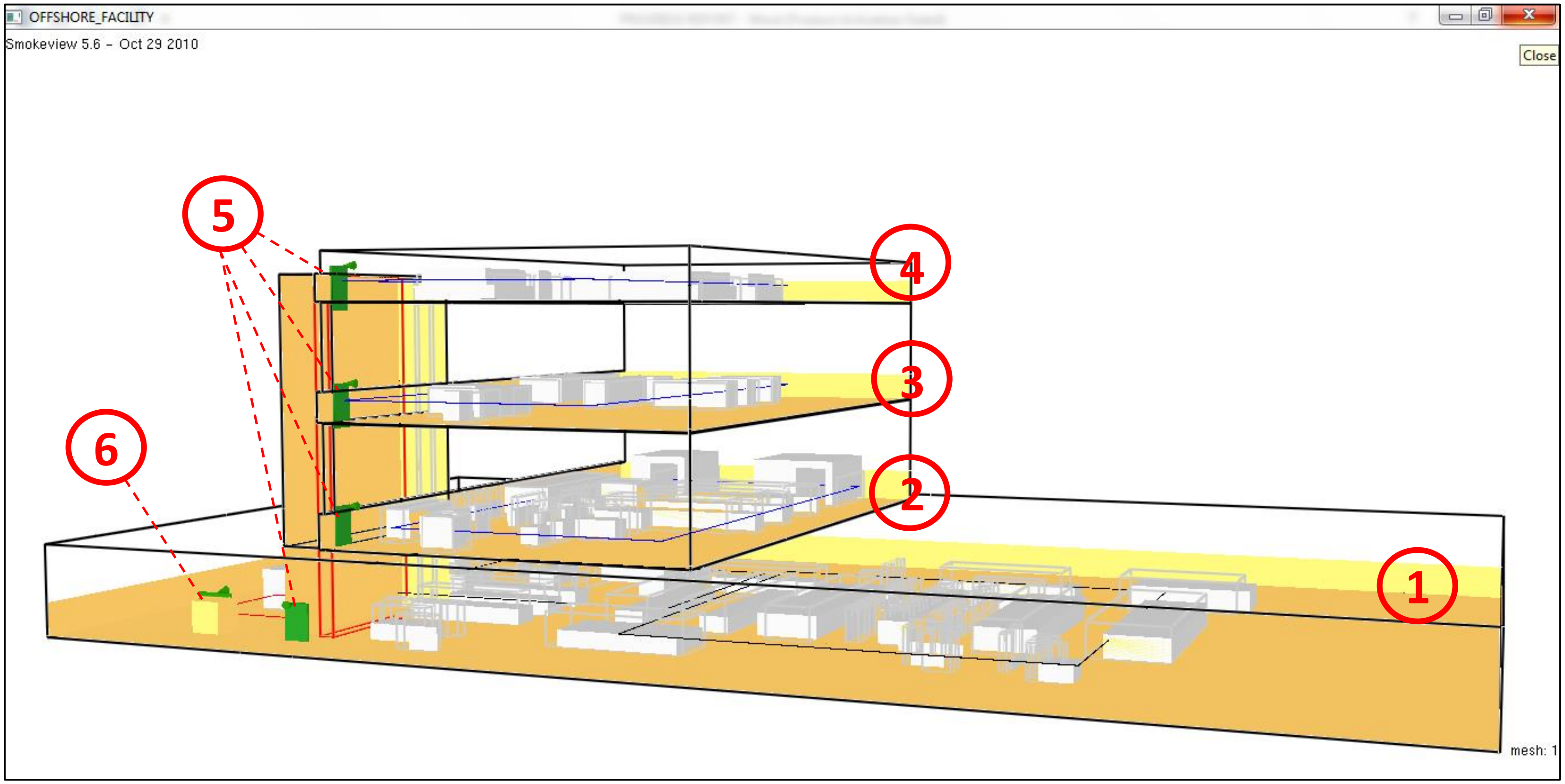
The researcher has vary mesh sizes in different simulations and hence two sets of preliminary results have been obtained. In the following sections, developed model description and preliminary model results will be covered.

4.1.1 Fully-Scaled Model of an Offshore Petroleum Facility

This project will assist the fire safety system of an offshore petroleum facility. Mainly, this facility extracts crude oil and gas from subsea reservoirs. This facility is equipped with numerous equipment for the process of processing, storage and transport of this combustible fuels.

This offshore facility has been constructed from four main decks with different dimensions and orientations (Appendix-I). Ground or main platform deck, second deck, third deck and fourth deck. Ground or main platform deck is the largest operation area with many equipment. It contains the most major and heavy equipment among other decks. In addition, number occupants in this area are relatively larger than other areas. Also, the number of hazardous equipment which working under high pressure are found to be more compared with other decks. The remaining decks (2^{nd}, 3^{rd} and 4^{th} decks) are essential as they complement the whole operation of the facility.

The researcher was able to develop the fully-scaled model successfully. All equipment's have been placed as built and found from the facility layout of the offshore facility. Figure (4-1) shows the fully-scaled developed model using CFD-FDS software.



1	Ground or Main Platform Deck	**4**	Fourth Deck
2	Second Deck	**5**	Evacuation Exits
3	Third Deck	**6**	Main Assembly Area

Figure 4-1: Fully-scaled model of the offshore facility layout

Each deck has a specific exit that occupants have to evacuate through it which is appeared in the model above with green vertically-placed surface. Figure (4-2) below shows evacuation exits sample of the fourth floor. The conical shape is the exit sign that occupants will see and cause them to move toward the exits. Occupants from upper decks will evacuate through the specific exits in each deck. Afterwards, through the staircase (see figure 4-3) they will head to the main assembly area for the escape stage by any escape means available in the offshore facility. Figure (4-3) shows exits of each deck, staircase mesh with occupants running and main assembly area of the offshore facility.

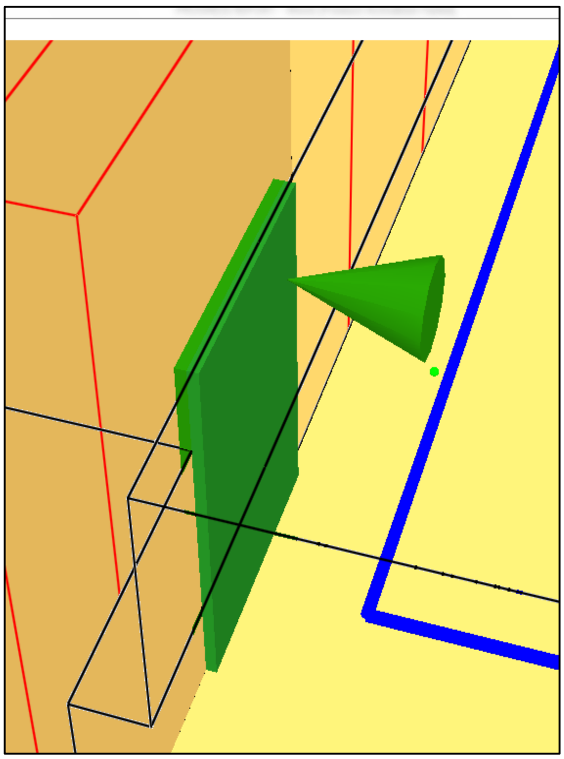


Figure 4-2: Evacuation exit for the fourth floor with the exit sign.

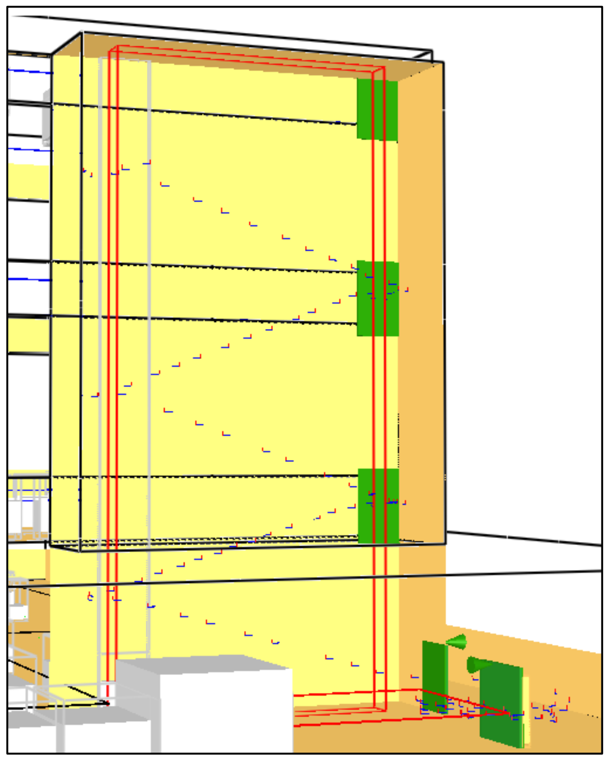


Figure 4-3: Evacuation process in the staircase mesh and the Main assembly area.

4.1.2 Input Assumption for the Offshore Facility Model

The researcher have successfully developed the model by through the input file (Appendix-II) from the obtained as built facility layout with the necessary dimensions and equipment positions. Several assumption have been made through model development process. Some of these minor assumption made cannot affect the expected results. Assumption made can be found as per below:

- **Equipment Height**

  As mentioned before, the model has been developed from as built facility layout which allow to see top view with two dimensions. The researcher has made assumption based on real similar equipment's height. Majority of the equipment height is in the range of 1.0-2.0 meters. Table (4-1) below shows some of the assumed values of the developed equipment.

Table 4-1: assumed values for equipment's' heights.

Equipment	Deck Level	Assumed height (meters)
Production separation	Ground	1.30
Warm Gas Flare Scrubber	Ground	1.50
Cold Gas Flare Scrubber	Ground	1.50
Test Separator	Ground	1.30
WH/1-WH/21 – Gas Manifold	2nd Deck	1.50
Fuel Gas Scrubber	2nd Deck	1.50
Fuel Gas Pre-heater	2nd Deck	1.30
Condensate Metering Skid System	2nd Deck	1.50
Booster Compressor	3rd Deck	1.50
Tank-1	4th Deck	1.50

- **Number of Occupants**

  Based on obtained data from reliable resources, it is found that the total number of occupants in the range of 210 – 240 occupants. Researcher have selected an average value of 220 occupants distributed in the four decks. Obviously, ground or main platform deck has the largest number of individuals as a result of the large area. Table (4-2) below shows the assumed number of individuals for each deck.

Table 4-2: assumed values for each deck occupant number

Deck Level	Number of Individuals	Remark
Ground / Main Platform Deck	**120**	Main deck and include all major facility equipment.
Second Deck	**40**	Include metering systems and instrument marshalling room, electric rooms with set of turbine.
Third Deck	**30**	Contains main separation equipment (suction scrubber, Glycol separator…etc.)
Fourth Deck	**30**	Contains platform air conditioning system equipment.
TOTAL	**220 occupants**	

- **Fire Properties & Allocation**

As mentioned before, this platform is an offshore facility that extracts crude oil and gas from subsea reservoirs for further processing and export purposes. Hence, installed facility equipment can be divided into two major categories. The first deals with crude oil processing and the second deals with gas processing. For simplicity, the researcher has applied the same properties for all resultant fire. All burners installed within the CFD-FDS input file is assumed to be a crude oil.

In fact, many equipment are operating under extremely high pressure and temperature. Fire event may occur as a result of the accident release of crude oil, gas, diesel or any combustible fuels from small opening which can later on cause risk. The researcher have identified the key equipment which can lead for an supremely hazardous fire event as a result of accident release or due another motives. Table (4-3) below shows the equipment in which will start-up the fire event and causing adjacent equipment to burn when they reach their ignition temperature. In addition, the researcher has ignored ignition of water-equipped tanks and equipment since the ignition from such equipment cannot lead for a series tragedy as compared with combustible fuels equipped equipment.

Table 4-3: assumed self-ignited equipment

Deck	Equipment
Ground / Main Platform Deck	Warm Gas Flare Scrubber
	Slug Catcher #1
	Diesel Day Tank
	Turbine Generator Area
	Gas Manifold Header - WH-10
2nd Deck	Condensate Metering Skid System
	2WS-595 Equipment
3rd Deck	Separator Skid
	Suction Scrubber#2
4th Deck	HAI-GH Equipment
	GLYCOL Contactor
	Discharge Cooler

Fire from these hazardous equipment will cause adjacent equipment to burn as they reach their specific ignition temperature. Crude oil specific temperature is found to be 28°C in which the researcher has specified this value for all adjacent equipment within the model CFD-FDS input file.

Equipment is consisting from two main components. The first is the equipment shell which is made from stainless steel with the following specifications:

- Density = 7750 kg/m^3
- Specific Heat Capacity = 0.502 kJ/kg.K
- Conductivity (k) = 16.2 W/m.K
- Thickness = 0.05 m = 5 cm

The second component is the burner which is contains the crude oil (combustible fuel). Hence, when firs occur within the above-mentioned table (4-3), adjacent equipment will catch some of the produced thermal radiation of the produced fire. Therefore, the incident heat flux in the adjacent equipment will cause the outer surface of the equipment to increase the temperature and heat will transfer through conduction from the outer shell through the thickness to burner and case another fire. Figure (4-4) shows an interpretation of the process of firing adjacent equipment in the CFD-FDS model through the entered input file commands.

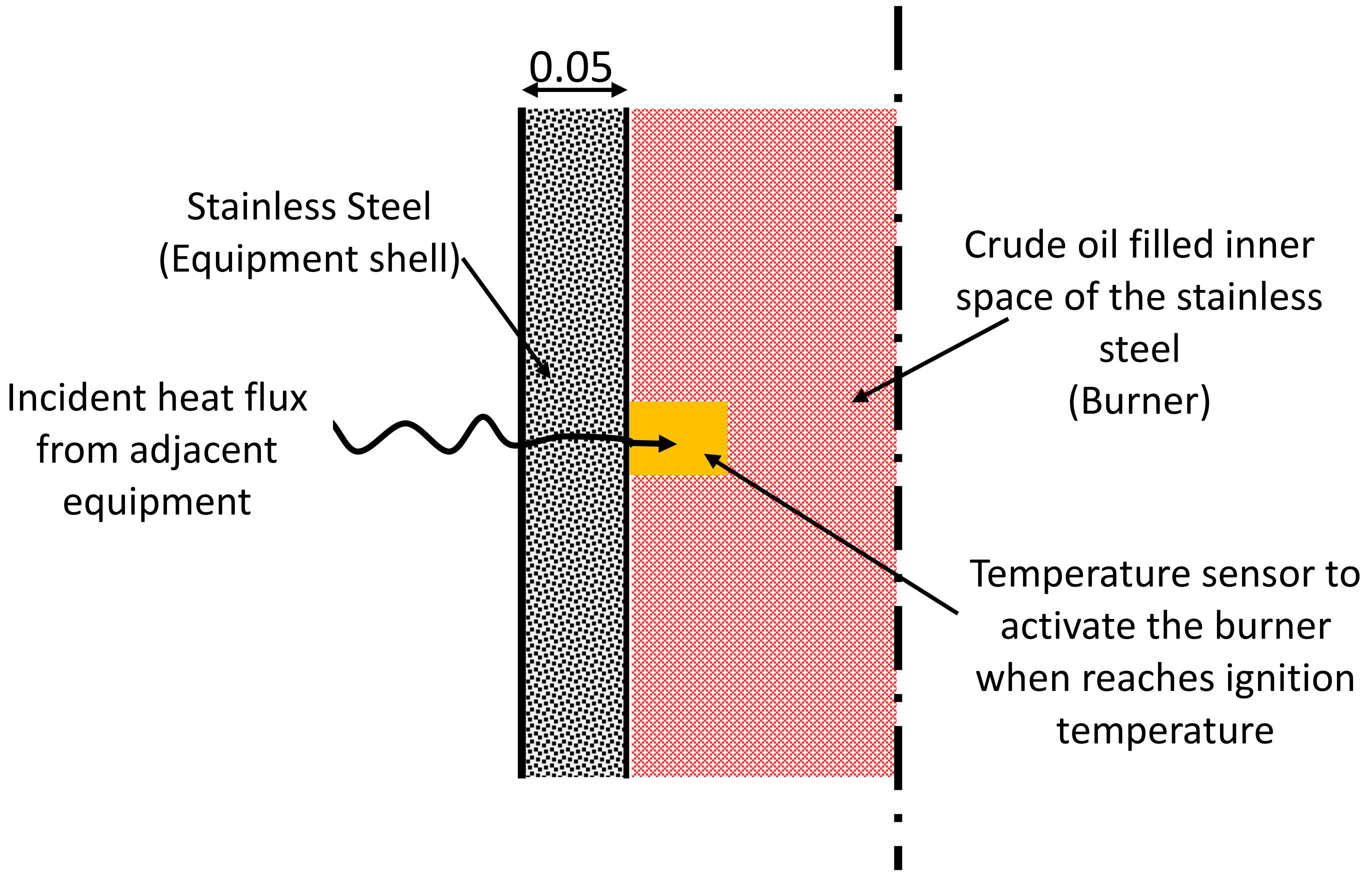


Figure 4-4: Cross section of Facility equipment modeling

For example, the equipment in the main platform deck named Warm Gas Flare Scrubber, as mentioned before, it is self-igniting in the model. As a result, adjacent equipment such as Cold Gas Flare Scrubber (CGFS) and Production Separation will ignite when the placed sensor inside the equipment in the burner side reaches the value of the ignition temperature of the crude oil and activate the fire. Crude oil ignition temperature is found to be 28°C from literature. Table (4-4) below shows some of the obtained temperature values for the placed sensor inside the equipment in the burner side for the Cold Gas Flare Scrubber.

Table 4-4: shows time of CGFS equipment reaches ignition temperature

FDS Time (s)	1ST_COLD_GAS _FLARE_SCUB (°C)	FDS Time (s)	1ST_COLD_GAS _FLARE_SCUB (°C)
0.00	20.00	12.00	15.38
0.62	20.00	12.61	15.97
1.21	20.00	13.20	18.86
1.81	20.00	13.80	22.25
2.40	20.02	14.41	22.78
3.01	20.04	15.00	22.04
3.61	20.01	15.60	21.08
4.21	20.04	16.21	20.12
4.81	20.22	16.80	19.71
5.41	20.56	17.41	20.22
6.00	20.91	18.01	21.43
6.61	21.32	18.60	23.85
7.20	21.56	19.21	29.37
7.81	21.46	19.80	40.79
8.40	20.96	20.40	68.03
9.00	20.04	21.01	107.38
9.61	18.24	21.60	129.19
10.21	17.65	22.20	130.37
10.81	17.12	22.81	125.34
11.41	15.95	23.40	136.52
12.00	15.38		
12.61	15.97		

As per table (4-4), at t=18.60 seconds the equipment burner temperature is 23.85°C , when temperature reaches 29.37°C, the equipment burner flash and burn as temperature is drastically increases with time.

4.1.3 Evacuation Time

The researcher has successfully run the CFD-FDS model with two different mesh sizes. The first is named as Coarse Mesh and the second is the Fine Mesh. Both results findings are correct but Fine Mesh results are very accurate. In fact, running the model with Coarse

Mesh size will take a complete day and few hours while Fine Mesh model needs a complete 2 days and few hours.

- **Evacuation Time From Coarse Mesh Model**

Figure (4-5) below shows the obtained results from the coarse mesh model. The total number of all occupants in all decks were 220 individuals. It took merely 191 seconds (3.18 minutes) for the whole evacuation process.

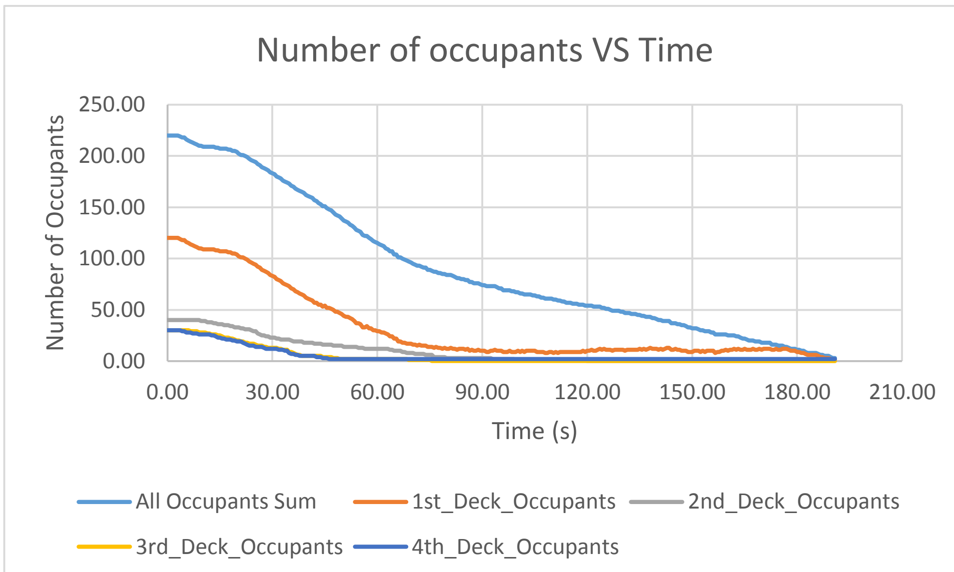


Figure 4-5: Occupants evacuation process versus time (Coarse mesh)

- **Evacuation Time From Fine Mesh Model**

Figure (4-6) below shows the obtained results from the fine mesh model. The total number of all occupants in all decks were 220 individuals. It took merely 4 minutes (248 seconds) for the whole evacuation process. The simulation needs few more minutes to complete but as per figure (4-6) only few occupants are still heading toward the exit (main assembly area).

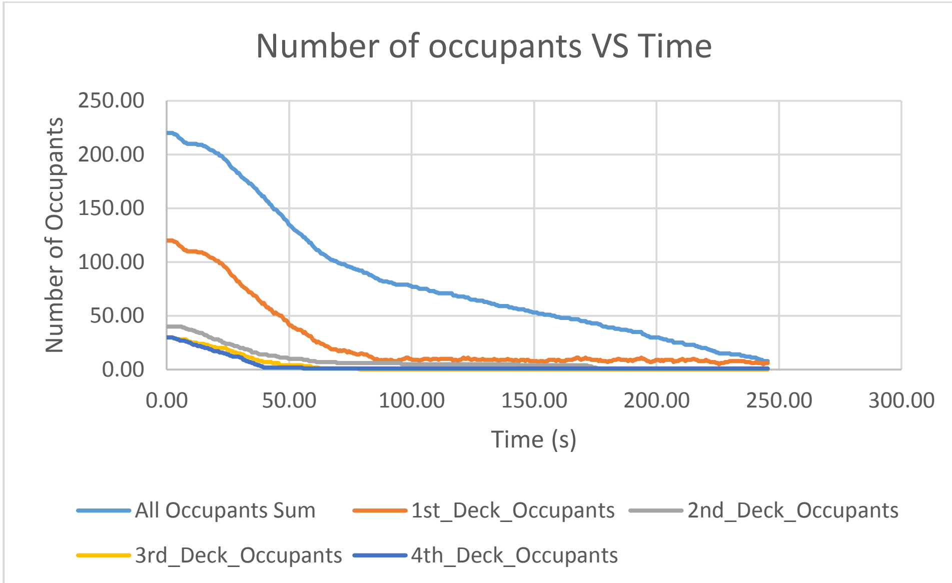


Figure 4-6: Occupants evacuation process versus time (Fine mesh)

Table (4-5) below is showing the summary of the total evacuation time obtained from both model and compare with the real data obtained from oil and gas industry common standard. In fact, it has been specified that the total evacuation time for the offshore facility platform to be 4 minutes. Hence, with respect to the above-mentioned findings, the fine mesh model have been validated to have an error percentage of 3.33%, but the coarse mesh has 20.41% error percentage.

Figure 4-5: Evacuation time for coarse and fine mesh

Comparison	**Coarse Mesh Model**	**Fine Mesh Model**
Evacuation Time (sec)	191 sec	248 sec
Error Percentage (%) $= \frac{\boldsymbol{4\ mins\ (PETRONAS\ Std) - Tevac}}{\boldsymbol{4\ mins\ (PETRONAS\ Std}}$	20.41%	3.33%

4.1.4 Evacuation Route (Egress)

The researcher has placed thermocouple temperature sensors along the path of occupants toward the main assembly area. Figure (4-7) and (4-8) shows the temperature trends versus the simulation time for the fine mesh model. It is obvious that all temperature trends results should be taken from fine mesh model which has been validated with 3.33% error percentage.

- **Ground deck evacuation route**

  This deck carry a total amount of 110 occupants. The placed thermocouples along the evacuation route have detected normal temperature measurements except for one device has found to have a very high temperature above 450°C. Figure (4-7) shows that a number of 71 occupants would be in critical situation if they exposed for such high temperature.

- **Upper decks evacuation route**

  As previously stated that total number of occupants for the whole offshore facility is 220 individuals. The ground deck carry a total of 110 occupants and the rest of upper decks carry 110 individuals also. It is clear from figure (4-8) that the evacuation of the 110 from upper decks is very safe. Temperature trends are found very acceptable and exposure of such incident heat flux will not cause any harmful issues. Moreover, propagation of such incident heat flux into adjacent equipment will not lead to a major consequences.

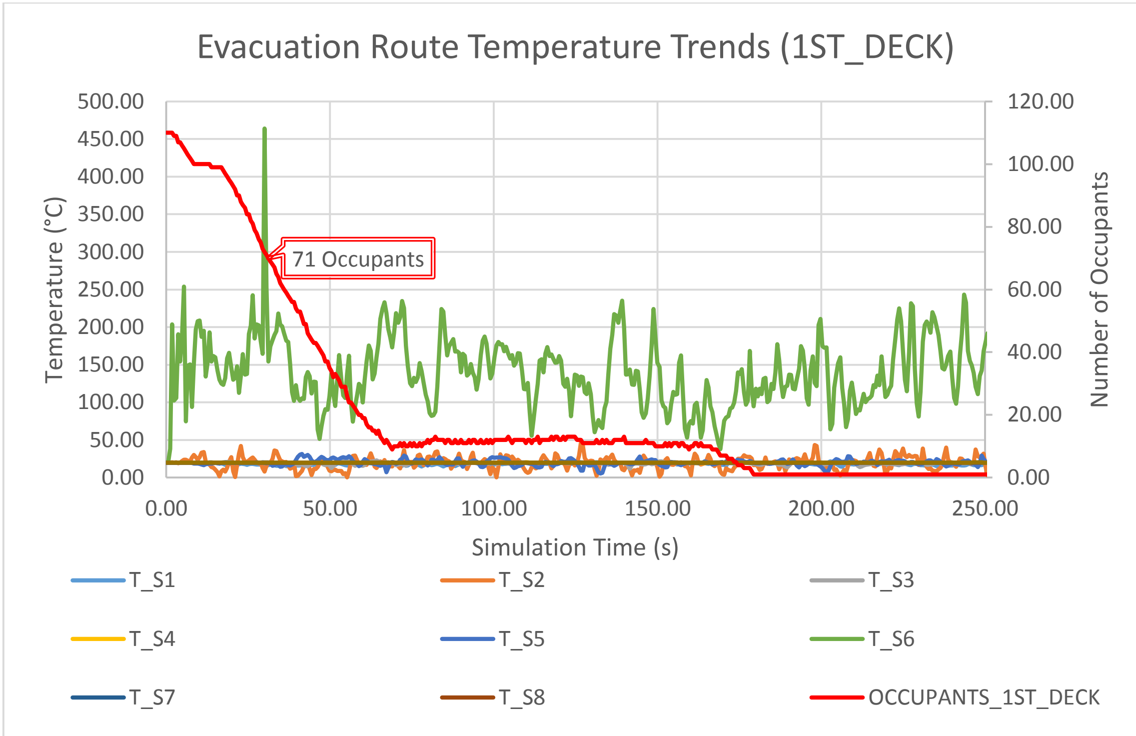


Figure 4-7: Evacuation route temperature trends (Ground – Fine Mesh)

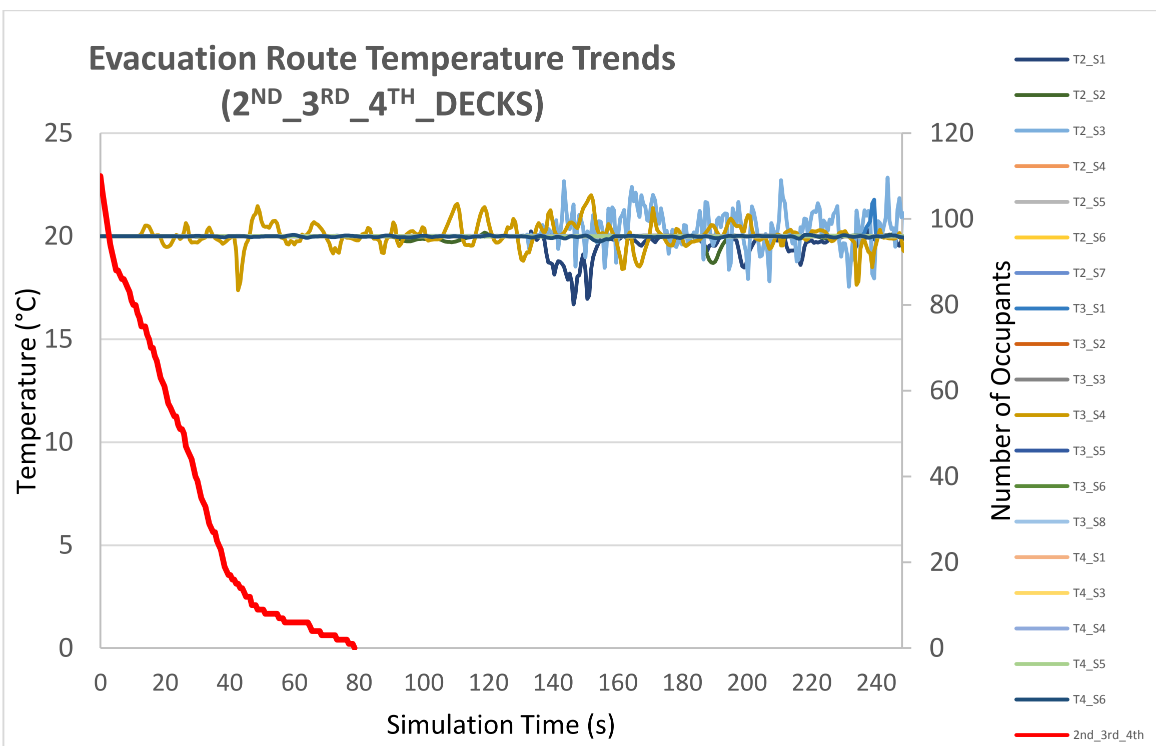


Figure 4-8: Evacuation route temperature trends (2^{nd}, 3^{rd} & 4^{th} Deck – Fine Mesh)

4.2 DISCUSSION

The main aim of this research is to assess the fire safety system of an offshore facility, determine the most beneficial and safest evacuation route for the safety of occupants. Evacuation time is very crucial especially in the case of large hydrocarbons fire. The developed CFD-FDS model has successfully determine the required time to evacuate the whole operation area within the offshore facility. Two sets of results have been obtained as the researcher used two mesh types (coarse and fine mesh). In fact, more accurate results will be obtained by using the fine mesh.

The developed model when running by using coarse mesh size, it takes the simulation about one complete day and few hours to end. While using fine mesh size instead, it takes the simulation for a complete 2 days and few hours. It is found that, for the fine mesh size model, that the evacuation time matches common standards of evacuation in oil and gas indsutry in which we can approve the model validity. The following sections will interpret more above model findings.

4.2.1 Evacuation Time

As have been found, the whole evacuation process should take 4 minutes (common standards of evacuation process in oil and gas industry) for any offshore facility. As per table (4-5) that fine mesh is more accurate that coarse mesh results with respect to the common standards of oil and gas, fine mesh error percentage is 3.33%.

In fact, it is essential to have a proper evacuation duration since with time the situation might lead for a disaster. Propagation of high thermal radiation might lead to another fire in which in a large period of time this might affect fire distribution and then distract evacuation process. Meanwhile, all occupants tend to find a safe route in which this shall affect evacuation time.

Moreover, length and width of those routes are affecting evacuation time. 110 occupants in the model are using the staircase to reach the main assembly area. In which, half of total number of occupants spent more than 70% of the total evacuation time in the staircase. Hence, by having another staircase this will allow to reduce human intensity and finally decrease the evacuation time.

In addition, fire development through the propagation of thermal radiation will affect the visibility in some facility locations. In which, human way for the main assembly area will be blocked and hence the evacuation time will be increased.

4.2.2 Evacuation Route (Egress)

The produced thermal radiation from fire is considered the main hazard for occupants, equipment and environment. This incident heat flux produced might entertain to produce another fire by heating adjacent equipment to its ignition temperature. In addition. Occupants' exposure to the incident heat flux can cause serious injuries (e.g. first degree burn, second degree burn) to the occupants.

Evacuation routes should be safe for occupants against the adverse effects of the produced thermal radiation. Hence, safety measurements should be taken to distinguish the most safe evacuation route if any or to minimize the effects of the produces thermal radiation by any means of fire prevention to protect occupants along the evacuation path.

Temperature sensors have been placed along the evacuation routes of occupants in all decks. This to assure that those evacuation routes are safe and efficient for evacuation purposes. Basically, as per figure (4-7), it is found that temperature trends in the ground deck to be normal except in single place has the coordinates of x= 15.0, y= 15.0, z= 6.0 (temperature sensor #6). 71 Occupants will expose for a temperature of 300°C and as per the literature review, that human exposure for such heat for only 1 seconds will cause a major fatality (death, 1st degree burn). Moreover, this should lead for a serious disaster since this temperature trends is sufficient to ignite many equipment and end with total human and property loss.

On the other hand, upper decks evacuation process should be done safely since all placed temperature sensors have detected normal temperature for human and equipment. Fire preventive measurements should be taken in the detected location. In fact, fire cannot be stopped from occurring, but preventive measurements are essential. For the high temperature of 300°C detected, a thermal resistance wall should be placed in this position so that the total of 71 occupants will not be affected by fire determinate effects.

CHAPTER FIVE

CONCLUSION & RECOMMENDATION

5.1 CONCLUSION

The main objective of this research is to assess the fire safety system of an offshore facility, offshore petroleum facility, and determine the most beneficial and safest evacuation route for occupants. A CFD-FDS model of an offshore petroleum facility has successfully developed and thus the intended objectives of this research is achieved. Further results analysis should be made for more detailed findings and measures to assess the current system deficiency and provide recommendation for better fire prevention means.

The researcher has used two different mesh sizes (coarse and fine mesh) and thus obtained two set of results. Compared with the common safety standards of evacuation process which require 4 minutes to evacuate the whole offshore facility, it is found that error percentage of fine and coarse mesh is 3.33% and 20.41% respectively.

Evacuation routes during the fire event have to be safe for occupants to go through without entertaining any high incident heat flux from the produced thermal radiation. Of course, fire events and thus the produced thermal radiation cannot be stopped or predicted. However, preventive means should be taken in order to reduce the risk. The researcher have found that evacuation through the ground deck is unsafe and preventive measurements should be taken for the specified location of this coordinates x=15.0, y=15.0, z=6.0. 71 occupants will expose for 300°C and exposure for such heat will cause a serious fatality. On the other hand, evacuation from upper decks is found to be safe and without risk.

Lastly, the objectives of this project have successfully achieved within scope and time constraints. The most efficient and safest evacuation route and time were successfully obtained. The produced thermal radiation was investigated and preventive measurements should be taken in the specified location.

5.2 RECOMMENDATION

The main two criterion for any evacuation process is the evacuation timing and routes. It is more efficient to have a reasonable evacuation time that will allow all occupants to safely evacuate. However, in some situations, as time is increased the situation might get worse by having many fire from a single event. It was obvious that, as occupants are using the same staircase and around 70% of the total evacuation time is spent on the staircase for occupants, it is recommended to have another staircase in different location. Thus, this will ensure more safety practice in case of more risky fire event and will allow to reduce the evacuation time for more reasonable value.

Moreover, it is recommended to have a thermal resistance wall installed in the position of the high thermal radiation detected in order to prevent human injury or propagation of such heat to adjacent equipment. Specifications of such thermal resistance wall should take into account amount of incident heat flux and duration of exposure.

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APPENDIX

Appendix-I: Model Input File

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&MESH IJK=43,25,28,XB=13.5,30.9, 2.1,32.1,10.0,15.4 / 174,100,114

&MESH IJK=43,25,28,XB=13.5,30.9, 2.1,32.1,15.6,20.74 /

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     EVACUATION=.TRUE., EVAC_HUMANS=.TRUE., ID='1stfloorgrid'/

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     EVACUATION=.TRUE., EVAC_HUMANS=.TRUE., ID='staircase'/


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MISC EVACUATION_DRILL=.TRUE. /
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&SURF ID='Outflow.',
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     TAU_V=0.1/
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&DUMP RENDER_FILE='OFFSHORE.ge1', DT_RESTART=300.0/
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&TIME T_END=600./

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&MATL ID='STAINLESS_STEEL'
CONDUCTIVITY=16.2
SPECIFIC_HEAT=0.502
DENSITY=7750./

&MATL ID ='BUILDING'
CONDUCTIVITY =0.07
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DENSITY=230./

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          BACKING='VOID'
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MATL_ID='CONCRETE_STONE'
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BACKING='VOID'
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&SURF ID='EQUIPMENT'
MATL_ID='STAINLESS_STEEL'
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&SURF ID='BURNER1',HRRPUA=1700./ Gas burner

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&OBST XB=43.88329,49.561529,25.38917,28.63388,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/  Warm Gas Flare Scrubber
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&OBST XB=43.88329,49.561529,25.38917,28.63388,5.0,6.5,
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&OBST XB=45.099,48.668,11.843,21.739,5.0,6.5,COLOR='GRAY 80', SURF_ID='INERT'/ Cold Gas Flare Scrubber
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&DEVC ID='1ST_COLD_GAS_FLARE_SCUB', XYZ=47.0,21.639,6.3, PROP_ID= 'HEAT'/
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27.0,9.5,6.0
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SURF_IDs='BURNER1','BURNER1','INERT'/Burner
-----------------------------------------------------------------------------

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&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
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&OBST XB=13.952,16.872,4.867,5.516,5.0,6.3, COLOR='GRAY 80', SURF_ID='INERT'/ Fuel Gas Filter Separator Skid

&OBST XB=13.627,14.601,6.651,7.300,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ FWM- FINEWATER Mist Cabinet (left-left-left)

&OBST XB=15.087,16.061,6.651,7.300,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ FWM- FINEWATER Mist Cabinet (right-right-right)

&OBST XB=16.548,17.521,6.651,7.300,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ FWM- FINEWATER Mist Cabinet middel

&OBST XB=16.4922,18.1957,2.919588,3.568529,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Lube Oil Cooler

&OBST XB=31.39117,31.87788,25.30805,25.957,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Future Pump-1

&OBST XB=31.39117,31.87788,26.443705,27.092647,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Future Pump-2

&OBST XB=31.39117,31.87788,27.579,28.22829,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Future Pump-3

&OBST XB=31.1478,32.3645,22.3878,23.52347,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ 3WS-115

&OBST XB=37.799,39.74629,9.571235,9.9768,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Nearby Wellhead Control - Lenght of 2388 scale

&OBST XB=37.9617,38.61064,7.786647,8.435588,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Instrument Air Reciever-1

&OBST XB=38.61064,39.259588,8.03,8.43558,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Instrument Air Reciever-2

&OBST XB=39.259588,40.47635,6.704176,7.8398235,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Note-3

&OBST XB=39.5029,40.233,8.251,9.062176,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Panel

&OBST XB=42.34205,42.74764,8.76005,10.0579,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Stuffing W/Regulator

&OBST XB=42.34205882,42.58541176,7.462176,8.27335,5.0,6.0, COLOR='GRAY 80', SURF_ID='INERT'/ Ignnitor Panel

&OBST XB=43.63994,45.6245,5.8398,7.7866,5.0,5.2, SURF_ID='INERT', COLOR='IVORY BLACK'/ Chemical Injection Skid

&OBST XB=43.88329,44.45111,6.083176,6.651,5.2,6.2, COLOR='GRAY 80', SURF_ID='INERT'/ Chemial Injection-1

&OBST XB=43.88329,44.45111,6.97547,7.54329,5.2,6.2, COLOR='GRAY 80', SURF_ID='INERT'/ Chemial Injection-2

&OBST XB=43.88329,44.61335294,7.786647,8.192235294,5.2,6.2, COLOR='GRAY 80', SURF_ID='INERT'/ Chemial Injection-3

&OBST XB=44.7755,45.18117,6.083176,6.651,5.2,6.2, COLOR='GRAY 80', SURF_ID='INERT'/ Chemial Injection-4

OBST XB=5.3534,5.84011,5.59707,9.328488,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Emergency Generator

&OBST XB=4.38,7.38135,10.058547,12.97878,5.0,7.5, COLOR='GRAY 80', SURF_ID='INERT'/ Battary Room

&OBST XB=4.9478235,7.300235,12.97878,14.844488,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Air Compressor 8C-490B

&OBST XB=4.9478235,7.300235,15.006723,16.87242941,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Air Compressor 8C-490A

&OBST XB=10.058235,11.275,15.25007647,16.223488,5.0,6.5,COLOR='GRAY 80', SURF_ID='INERT'/ Feed Water Pump 4P-420B

&OBST XB=10.158,11.175,15.35,16.12,5.0,6.3,SURF_IDs='BURNER1','BURNER1','BURNER1',
DEVC_ID='1ST_FEED_WATER_PP_B', EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_FEED_WATER_PP_B', XYZ=11.175,15.8,6.3, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

&OBST XB=10.058235,11.275,17.11578,18.00807,5.0,6.5,COLOR='GRAY 80', SURF_ID='INERT'/ Feed Water Pump 4P-420A

&OBST XB=10.158,11.175,17.215,17.90,5.0,6.3,SURF_IDs='BURNER1','BURNER1','BURNER1',
DEVC_ID='1ST_FEED_WATER_PP_A', EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_FEED_WATER_PP_A', XYZ=11.175,17.56,6.3, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

&OBST XB=10.058235,11.275,18.90037,19.79266,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Feed Water Pump 4P-420C

&OBST XB=10.158,11.175,19.1,19.6,5.0,6.3,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_FEED_WATER_PP_C', EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_FEED_WATER_PP_C', XYZ=11.175,19.4,6.3, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

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&OBST XB=11.031647,11.59947,23.28072,24.497488,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/  Pot Water Pump 5P-460B

&OBST XB=11.031647,11.59947,25.38978,26.60654706,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/  Pot Water Pump 5P-460A

&OBST XB=5.02894,5.5967647,24.01078,24.41637059,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/  QUARTERS F.W.

&OBST XB=4.866705882,6.002352941,25.633135,26.8499,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Service Air Receiver

&OBST XB=30.661117,32.60794,11.11247,21.252176,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/  Gas Manifold Header
-------------------------------------------------------------------------------------------
&OBST XB=30.76,32.50,11.21,21.15,5.0,6.3,SURF_IDs='BURNER1','BURNER1','BURNER1',
DEVC_ID='1ST_GAS_MANIFOLD_HEAD', EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_GAS_MANIFOLD_HEAD', XYZ=32.50,14.0,6.3, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-------------------------------------------------------------------------------------------

&OBST XB=40.31411765,42.3420588,11.11247,21.252176,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/  Oil Manifold Header
-------------------------------------------------------------------------------------------
&OBST XB=40.41,42.24,11.21,21.15,5.0,6.3,SURF_IDs='BURNER1','BURNER1','BURNER1',
DEVC_ID='1ST_OIL_MANIFOLD_HEAD', EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_OIL_MANIFOLD_HEAD', XYZ=40.41,14.0,6.3, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
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                    ======== GAS MANIFOLD HEADER WH-1/WH-21=========

&OBST XB=37.961705,38.77288,20.441,21.25217,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-1
-------------------------------------------------------------------------------------------
&OBST XB=38.1,38.67,20.54,21.15,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_01',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_01', XYZ=38.1,20.8,6.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-------------------------------------------------------------------------------------------
&OBST XB=37.961705,38.77288,18.98088,19.79205,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-2
-------------------------------------------------------------------------------------------
&OBST XB=38.1,38.67,19.09,19.69,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_02',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_02', XYZ=38.1,19.3,6.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-------------------------------------------------------------------------------------------
&OBST XB=37.961705,38.77288,17.52076,18.33194,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-3
-------------------------------------------------------------------------------------------
&OBST XB=38.1,38.67,17.62,18.23,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_03',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_03', XYZ=38.1,17.9,6.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-------------------------------------------------------------------------------------------
&OBST XB=37.961705,38.77288,16.060647,16.87182,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-4
-------------------------------------------------------------------------------------------
&OBST XB=38.1,38.67,16.16,16.77,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_04',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_04', XYZ=38.1,16.45,6.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-------------------------------------------------------------------------------------------
&OBST XB=37.961705,38.77288,14.60052,15.4117,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-5
-------------------------------------------------------------------------------------------
&OBST XB=38.1,38.67,14.7,15.31,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_05',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_05', XYZ=38.1,15.0,6.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-------------------------------------------------------------------------------------------
&OBST XB=37.961705,38.77288,13.140411,13.95158,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-6
&OBST XB=37.961705,38.77288,11.68029,12.491471,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-7

&OBST XB=36.01488,36.82605,20.441,21.25217,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-8
-------------------------------------------------------------------------------------------
&OBST XB=36.1,36.72,20.54,21.15,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_08',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_08', XYZ=36.4,20.54,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-------------------------------------------------------------------------------------------
&OBST XB=36.01488,36.82605,18.98088,19.79205,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-9
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&OBST XB=36.1,36.72,19.09,19.69,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_09',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_09', XYZ=36.4,19.09,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------
&OBST XB=36.01488,36.82605,17.52076,18.33194,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-10

---------------------------------------------------------------------------------------
&OBST XB=36.01488,36.82605,17.52076,18.33194,5.0,6.5,
SURF_IDs='BURNER1','BURNER1','INERT'/Burner

---------------------------------------------------------------------------------------
&OBST XB=36.01488,36.82605,16.060647,16.87182,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-11
------------------------------------------------------------------------------------------
&OBST XB=36.1,36.72,16.16,16.77,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_11',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_11', XYZ=36.4,16.77,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------

&OBST XB=36.01488,36.82605,14.60052,15.4117,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-12
------------------------------------------------------------------------------------------
&OBST XB=36.11,36.7,14.7,15.31,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_12',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_12', XYZ=36.4,15.31,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------
&OBST XB=36.01488,36.82605,13.140411,13.95158,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-13
------------------------------------------------------------------------------------------
&OBST XB=36.11,36.7,13.24,13.85,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_13',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_13', XYZ=36.4,13.85,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------
&OBST XB=36.01488,36.82605,11.68029,12.491471,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-14
------------------------------------------------------------------------------------------
&OBST XB=36.11,36.7,11.78,12.39,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_14',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_14', XYZ=36.4,12.39,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------

&OBST XB=34.06805,34.879235,20.441,21.25217,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-15
------------------------------------------------------------------------------------------
&OBST XB=34.168,34.79,20.54,21.15,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_15',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_15', XYZ=34.79,20.8,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------
&OBST XB=34.06805,34.879235,18.98088,19.79205,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-16
&OBST XB=34.06805,34.879235,17.52076,18.33194,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-17
------------------------------------------------------------------------------------------
&OBST XB=34.168,34.79,17.62,18.23,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_17',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_17', XYZ=34.79,18.0,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------
&OBST XB=34.06805,34.879235,16.060647,16.87182,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-18
------------------------------------------------------------------------------------------
&OBST XB=34.168,34.79,16.16,16.77,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_18',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_18', XYZ=34.79,16.5,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------
&OBST XB=34.06805,34.879235,14.60052,15.4117,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-19
------------------------------------------------------------------------------------------
&OBST XB=34.168,34.79,14.7,15.51,5.0,6.4,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='1ST_WH_19',
EVACUATION=.FALSE./ Burner
&DEVC ID='1ST_WH_19', XYZ=34.79,15.15,6.4, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
------------------------------------------------------------------------------------------
&OBST XB=34.06805,34.879235,13.140411,13.95158,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-20
&OBST XB=34.06805,34.879235,11.68029,12.491471,5.0,6.5, COLOR='GRAY 80', SURF_ID='INERT'/ Gas Manifold Header - WH-21

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DECK #2 EQUIPMENTS (OBSTECLES)

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&OBST XB=14.357,15.493,5.110,9.166,9.8,11.3, COLOR='GRAY 80', SURF_ID='INERT'/ 1WS-610 - Separator
-----------------------------------------------------------------------------------------
&OBST XB=14.45,15.39,5.21,9.06,9.8,11.2,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='2ND_1WS_SEPT',
EVACUATION=.FALSE./ Burner
&DEVC ID='2ND_1WS_SEPT', XYZ=15.39,7.0,11.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-----------------------------------------------------------------------------------------

&OBST XB=16.953,17.764,6.2459,7.0579,9.8,11.3, COLOR='GRAY 80', SURF_ID='INERT'/ Fuel Gas Scrubber
-----------------------------------------------------------------------------------------
&OBST XB=17.08,17.67,6.345,6.91,9.8,11.2,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='2ND_FUEL_GAS_SCRUB',
EVACUATION=.FALSE./ Burner
&DEVC ID='2ND_FUEL_GAS_SCRUB', XYZ=15.39,7.0,11.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-----------------------------------------------------------------------------------------

&OBST XB=17.602,19.143,3.1639,4.7059,9.8,11.3,COLOR='GRAY 80', SURF_ID='INERT'/ Crane Location to position the Hoisting
system

&OBST XB=19.2245,19.4678,9.9783,12.2483,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ Fuel Gas Pre-heater

&OBST XB=19.2245,19.4678,12.6399,15.1689,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ Fuel Gas Super-heater

&OBST XB=17.358,17.602,7.8699,9.0049,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ Fuel Gas Filters Scrubber

&OBST XB=14.52,15.089,11.2759,11.8439,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/

&OBST XB=14.1951,14.763,12.3306,12.8984,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ Condensate Collector#2

&OBST XB=14.1951,14.763,13.3849,13.953,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/

&OBST XB=14.1951,14.763,14.5208,15.0886,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ WS-6303 Collectors#2

&OBST XB=14.114,16.548,16.6299,24.7419,9.8,11.3,COLOR='GRAY 80', SURF_ID='INERT'/ Condensate Metering Skid System
---------------------------------------------------------------------------------------
&OBST XB=14.114,16.548,16.6299,24.7419,9.8,11.3,
SURF_IDs='BURNER1','BURNER1','INERT'/Burner
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&OBST XB=21.2523,21.9824,6.0026,7.301,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2WS-595#DOWN

---------------------------------------------------------------------------------------
&OBST XB=21.2523,21.9824,6.0026,7.301,9.8,10.8,
SURF_IDs='BURNER1','BURNER1','INERT'/Burner
---------------------------------------------------------------------------------------

&OBST XB=21.2523,21.9824,7.625,8.923,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2WS-595#UP
-----------------------------------------------------------------------------------------
&OBST XB=21.35,21.88,7.725,8.823,9.8,10.7,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='2ND_2WS_595_UP',
EVACUATION=.FALSE./ Burner
&DEVC ID='2ND_2WS_595_UP', XYZ=21.5,7.725,10.7, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-----------------------------------------------------------------------------------------

&OBST XB=22.145,24.172,9.328,10.0585,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2WM-504A

&OBST XB=17.27764,17.6732,11.5997,14.4388,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ Fuel Gas Filter 2F-6903

&OBST XB=17.9265,18.5755,15.6555,16.7912,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ SHE-620 CHEMICALS #DOWN

&OBST XB=17.9265,18.5755,17.4408,18.5758,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ SHE-620 CHEMICALS #UP

&OBST XB=17.802,19.9111,20.198,22.3072,9.8,11.3,COLOR='GRAY 80', SURF_ID='INERT'/ 2V-620 Glycol
-----------------------------------------------------------------------------------------
&OBST XB=17.9,19.81,20.29,22.2,9.8,11.2,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='2ND_GLYCOL_2V_620',
EVACUATION=.FALSE./ Burner
&DEVC ID='2ND_GLYCOL_2V_620', XYZ=17.9,21.0,11.2, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-----------------------------------------------------------------------------------------

&OBST XB=21.333,27.741,13.7899,15.737,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas
-----------------------------------------------------------------------------------------
&OBST XB=21.43,27.6,13.88,15.63,9.8,10.7,SURF_IDs='BURNER1','BURNER1','BURNER1',
DEVC_ID='2ND_2C_586_ASSOC_GAS_1', EVACUATION=.FALSE./ Burner
&DEVC ID='2ND_2C_586_ASSOC_GAS_1', XYZ=21.43,14.5,10.7, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/
-----------------------------------------------------------------------------------------
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&OBST XB=21.009,21.333,14.7633,15.737,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas
&OBST XB=27.741,28.715,14.2766,15.2501,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas
&OBST XB=21.333,23.767,12.329,13.7899,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas

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&OBST XB=21.739,27.741,17.4403,19.3059,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas
----
&OBST XB=21.83,27.6,17.54,19.405,9.8,10.7,SURF_IDs='BURNER1','BURNER1','BURNER1',
DEVC_ID='2ND_2C_586_ASSOC_GAS', EVACUATION=.FALSE./ Burner
&DEVC ID='2ND_2C_586_ASSOC_GAS', XYZ=21.83,18.0,10.7, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

&OBST XB=27.741,28.715,17.927,18.9005,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas

&OBST XB=22.550,23.2803,19.0,19.630,10.0,10.65,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas

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&OBST XB=21.739,27.741,21.253,23.11836,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas
----
&OBST XB=21.83,27.6,21.35,23.10,9.8,10.7,SURF_IDs='BURNER1','BURNER1','BURNER1',
DEVC_ID='2ND_2C_586_ASSOC_GAS_2', EVACUATION=.FALSE./ Burner
&DEVC ID='2ND_2C_586_ASSOC_GAS_2', XYZ=21.83,22.5,10.7, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

&OBST XB=27.741,28.715,21.9828,22.9563,9.8,10.8,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas

&OBST XB=22.550,23.2803,23.0,23.8,10.0,10.65,COLOR='GRAY 80', SURF_ID='INERT'/ 2C-586 Associated Gas

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&OBST XB=23.982,28.47182,26.6597,31.149,9.8,12.3, COLOR='GRAY 80', SURF_ID='INERT'/
&HOLE XB=26.49,27.99,26.6597,30.449,9.8,11.9/

&OBST XB=16.8721,19.8734,26.5253,30.743,9.8,12.3, COLOR='GRAY 80', SURF_ID='INERT'/
&HOLE XB=17.96,19.4874,26.5253,30.3,9.8,12.0/

&OBST XB=4.6235,12.573,28.39105,32.52805,9.8,12.3, COLOR='GRAY 80', SURF_ID='INERT'/
HOLE XB=17.96,19.4874,26.5253,30.3,9.8,12.0/

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DECK #3 EQUIPMENTS (OBSTECLES)

OBST XB=13.384,20.279,2.839,26.0,14.639,15.439, SURF_ID='GROUND_BASE'/ Second Deck Ground-Floor - left

OBST XB=20.279,21.009,5.110,26.0,14.639,15.439, SURF_ID='GROUND_BASE'/ Second Deck Ground-Floor - middle

OBST XB=21.009,29.769,13.303,26.0,14.639,15.439, SURF_ID='GROUND_BASE'/ Second Deck Ground-Floor - right

&OBST XB=18.5755,19.7111,3.8124,4.9481,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Crane Position

&OBST XB=18.25105,19.0622,6.08370,7.54382,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Booster Compressor Seal Gas Filter 2F-595A/B

&OBST XB=18.25105,19.0622,8.67947,10.30182,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Booster Compressor Seal Gas Filter
2HX-695A

&OBST XB=15.168588,17.43988,7.86829,10.95046,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Transmission Compressor Dry Seal Gas Unit

&OBST XB=18.926588,20.062235,16.629,20.84711765,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Separator Skid
----
&OBST XB=18.926588,20.062235,16.629,20.84711765,15.439,16.939,
SURF_IDs='BURNER1','BURNER1','INERT'/Burner

&OBST XB=18.41329,20.52235,21.171588,23.199529,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Contactor Tower
----

&OBST XB=18.51,20.42,21.07,23.09,15.439,16.839,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='3RD_CONT_TOWER', EVACUATION=.FALSE./ Burner
&DEVC ID='3RD_CONT_TOWER', XYZ=19.0,21.07,16.839, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

&OBST XB=13.870705,16.46647,18.33247,25.22747,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ GLYCOL Processing
----
OBST XB=13.97,16.366,18.43,25.127,15.439,16.839,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='3RD_GLYCOL_PROCS', EVACUATION=.FALSE./ Burner
DEVC ID='3RD_GLYCOL_PROCS', XYZ=16.366,20.0,16.839, PROP_ID= 'HEAT'/
PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

&OBST XB=22.14464,26.20052,17.52135,18.657,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Suction Scrubber
----
OBST XB=22.56,25.909,17.62,18.557,15.439,16.839,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='3RD_SUCT_SCRUB_1', EVACUATION=.FALSE./ Burner
DEVC ID='3RD_SUCT_SCRUB_1', XYZ=24.0,18.557,16.839, PROP_ID= 'HEAT'/
PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

&OBST XB=22.469117,26.03829,20.60382,21.57723529,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Suction Scrubber#2

&OBST XB=22.469117,26.03829,20.60382,21.57723529,15.439,16.939, SURF_IDs='BURNER1','BURNER1','INERT'/Burner
----

&OBST XB=22.469117,26.03829,23.36782,24.335235,15.439,16.939,COLOR='GRAY 80', SURF_ID='INERT'/ Suction Scrubber#3

&OBST XB=22.56,25.909,23.467,24.235,15.439,16.839,SURF_IDs='BURNER1','BURNER1','BURNER1', DEVC_ID='3RD_SUCT_SCRUB_3', EVACUATION=.FALSE./ Burner
&DEVC ID='3RD_SUCT_SCRUB_3', XYZ=24.0,24.235,16.839, PROP_ID= 'HEAT'/
&PROP ID= 'HEAT', QUANTITY= 'LINK TEMPERATURE', RTI =2, ACTIVATION_TEMPERATURE= 28/

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DECK #4 EQUIPMENTS (OBSTECLES)

OBST XB=13.384,20.279,4.94806,26.0,19.963,20.763, SURF_ID='GROUND_BASE'/ Second Deck Ground-Floor - left

OBST XB=20.279,21.009,5.110,26.0,19.963,20.763, SURF_ID='GROUND_BASE'/ Second Deck Ground-Floor - middle

OBST XB=21.009,29.769,13.303,26.0,19.963,20.763, SURF_ID='GROUND_BASE'/ Second Deck Ground-Floor - right

&OBST XB=16.01964,19.8,5.92147,9.374001176,20.763,21.463,COLOR='GRAY 80', SURF_ID='INERT'/ Suction Cooler-1
&OBST XB=16.3196,19.5,6.2,9.08,21.463,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Suction Cooler-2

&OBST XB=17.2265,17.764,10.30182,11.43747,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Serace Platform

&OBST XB=18.1699,19.4678,10.30182,11.43747,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Removable Grating

&OBST XB=15.00635,15.81752,13.54653,14.35771,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Tank-1

&OBST XB=16.142,16.95317,13.54653,14.35771,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Tank-2

&OBST XB=17.27765,18.0888,13.54653,14.35771,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Tank-3

&OBST XB=18.41329,19.22447,13.54653,14.35771,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Tank-4

&OBST XB=17.76435,18.0888,14.682178,16.142295,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ HAI-GH

&OBST XB=17.76435,18.0888,14.682178,16.142295,20.763,22.263, SURF_IDs='BURNER1','BURNER1','INERT'/Burner
----

&OBST XB=15.81752,16.62871,15.331118,16.142295,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ nearby HAI-GH#1

&OBST XB=16.95317,17.7643529,15.331118,16.142295,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ nearby HAI-GH#2

&OBST XB=13.546235,14.03294,14.03323,14.5199,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Host Oil Traces

&OBST XB=14.19517,15.574176,17.764648,22.956177,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ GLYCOL Receiver 2HX-605
&OBST XB=16.628705,20.03565,18.251354,21.658295,20.763,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ GLYCOL Contactor
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&OBST XB=16.628705,20.03565,18.251354,21.658295,20.763,22.263,
SURF_IDs='BURNER1','BURNER1','INERT'/Burner
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&OBST XB=21.414588,26.03829,14.276411,19.143471,20.763,21.563,COLOR='GRAY 80', SURF_ID='INERT'/ Discharge Cooler
&OBST XB=21.724588,25.78829,14.576411,18.793471,21.563,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Discharge Cooler

&OBST XB=21.25235,26.038294,21.3057,24.821705,20.763,21.563,COLOR='GRAY 80', SURF_ID='INERT'/ Discharge Cooler
&OBST XB=21.574588,25.73829,21.696411,24.503471,21.563,22.263,COLOR='GRAY 80', SURF_ID='INERT'/ Discharge Cooler

------------------------------------------------------------------------------------
&OBST XB=21.574588,25.73829,21.696411,24.503471,21.563,22.263,
SURF_IDs='BURNER1','BURNER1','INERT'/Burner
------------------------------------------------------------------------------------

================================================================================
&HOLE XB=1.72,2.758,16.0,19.08,9.0,9.8/
================================================
============= EVAC GEOMETRY STARTS ==================
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                    ======== FIRST FLOOR EVACUATION =========

&PERS ID='person', DEFAULT_PROPERTIES='Adult',
     PRE_EVAC_DIST=0, PRE_MEAN=0.5, VELOCITY_DIST=1,
     VEL_LOW=0.95,VEL_HIGH=1.19,
     COLOR_METHOD=0 / color using evac-line color
&VENT SURF_ID='Outflow.', XB=5.1,7.0,4.2,4.2,5.0,7.0,
     EVACUATION=.TRUE.,MESH_ID='1stfloorgrid'/ Exit Vent.

&VENT SURF_ID='Outflow.', XB=5.1,7.0,4.2,4.2,5.0,7.0,
     EVACUATION=.TRUE.,MESH_ID='GroundExit1'/ Exit Vent.
&OBST SURF_ID='INERT', XB=5.1,7.0,4.0,4.2,5.0,7.0, THICKEN=.TRUE./ Exit Ven

**************************************************************
******************* Staircase Core & STRS *******************
 Create the staircase core

&OBST XB= 11.5,12.2,  4.5,11.7, 4.0,20.0, COLOR='RED', EVACUATION=.TRUE.,
     PERMIT_HOLE=.FALSE., MESH_ID='staircase' /

&HOLE XB= 10.5,13.2,  3.3,12.9, 5.4,11.4, EVACUATION=.TRUE.,
     MESH_ID='staircase' /
 HOLE XB= 10.49,13.47,3.39,12.84,5.4,20.0, EVACUATION=.TRUE., /

 *STRS parameters*
 StrsMESH IJK=27,96,1,,XB=10.5,13.2,  3.3,12.9, 5.4,11.4,
&VENT SURF_ID='Outflow.', XB=13.2,13.2, 3.3,4.5, 10.6,10.6,
     EVACUATION=.TRUE.,MESH_ID='2ndfloorgrid'/ Exit Vent.
&VENT SURF_ID='Outflow.', XB=13.2,13.2, 3.3,4.5, 10.6,10.6,
     EVACUATION=.TRUE.,MESH_ID='2ndlevelExit2 '/ Exit Vent.

&VENT SURF_ID='Outflow.', XB=13.2,13.2, 3.3,4.5, 16.1195,16.1195,
     EVACUATION=.TRUE.,MESH_ID='3rdfloorgrid'/ Exit Vent.
&VENT SURF_ID='Outflow.', XB=13.2,13.2, 3.3,4.5, 16.1195,16.1195,
     EVACUATION=.TRUE.,MESH_ID='3rdlevelExit'/ Exit Vent.
&VENT SURF_ID='Outflow.', XB=13.2,13.2, 3.3,4.5, 21.3815,21.3815,
     EVACUATION=.TRUE.,MESH_ID='4thfloorgrid'/ Exit Vent.
&VENT SURF_ID='Outflow.', XB=13.2,13.2, 3.3,4.5, 21.3815,21.3815,
     EVACUATION=.TRUE.,MESH_ID='4thlevelExit'/ Exit Vent.
z_mid=10.6
&DOOR ID='exit2', FYI='staircase', XB=13.2,13.2, 3.3,4.5, 10.6,10.6, IOR=-1,
MESH_ID='2ndfloorgrid',EXIT_SIGN=.TRUE.,TO_NODE='staircase', KEEP_XY=.FALSE./
z_mid=16.1195
&DOOR ID='exit3', FYI='staircase', XB=13.2,13.2, 3.3,4.5, 16.1195,16.1195, IOR=-1, MESH_ID='3rdfloorgrid',
EXIT_SIGN=.TRUE.,TO_NODE='staircase', KEEP_XY=.FALSE./
z_mid=21.3815
&DOOR ID='exit4', FYI='staircase', XB=13.2,13.2, 3.3,4.5, 21.3815,21.3815, IOR=-1, MESH_ID='4thfloorgrid',
EXIT_SIGN=.TRUE.,TO_NODE='staircase', KEEP_XY=.FALSE./

&DOOR ID='StairsMainExit', FYI='staircase', XB=10.5,11.7, 3.3,3.3,6.1,6.2,
     IOR=+2, MESH_ID='1stfloorgrid', EXIT_SIGN=.FALSE.,TO_NODE='staircase'/

&STRS ID='Strs',
     XB= 10.5,13.2,  3.3,12.9, 5.4,22.0,
     XB_CORE= 11.5,12.2,  4.5,11.7,
     RIGHT_HANDED=.FALSE., MESH_ID='staircase',
     VERTICAL_LANDING_SEPARATION=2.55,  N_LANDINGS=7,
     XB_LANDINGS( 1,:)= 10.5,13.2,   3.3, 4.5,   6.1, 6.3,
     XB_LANDINGS( 2,:)= 10.5,13.2,  11.7,12.9,   8.3, 8.5,
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     XB_LANDINGS( 3,:)= 10.5,13.2,   3.3, 4.5,  10.5,10.7,
     XB_LANDINGS( 4,:)= 10.5,13.2,  11.7,12.9,  13.20975,13.40975,
     XB_LANDINGS( 5,:)= 10.5,13.2,   3.3, 4.5,   16.0195,16.2195,
     XB_LANDINGS( 6,:)= 10.5,13.2,  11.7,12.9,   18.6505,18.8505,
     XB_LANDINGS( 7,:)= 10.5,13.2,   3.3, 4.5,   21.2815,21.4815,
     FAC_V0_UP=0.4, FAC_V0_DOWN=0.60, FAC_V0_HORI=1.0, /
****************************************************************
&EVAC ID='operationteam1', XB=5.1,9.6,4.5,10.0,5.4,7.0, AVATAR_COLOR='RED',
     COLOR='RED',
     NUMBER_INITIAL_PERSONS=10, PERS_ID='person', MESH_ID='1stfloorgrid'/

&EVAC ID='operationteam2', XB=9.5,25.0,12.5,25.4,5.4,7.0,
     NUMBER_INITIAL_PERSONS=30, PERS_ID='person', MESH_ID='1stfloorgrid'/

&EVAC ID='operationteam3', XB=26.0,46.0,5.5,26.0,5.4,7.0,
    NUMBER_INITIAL_PERSONS=80, PERS_ID='person', MESH_ID='1stfloorgrid'/

&EXIT ID='exit1', FYI='staircase', XB=5.1,7.0,4.2,4.2,5.4,7.0, IOR=-2,
     MESH_ID='1stfloorgrid'/
            ======== SECOND FLOOR EVACUATION =========
&PERS ID='person02', DEFAULT_PROPERTIES='Adult', PRE_EVAC_DIST=0,
    PRE_MEAN=0.5, VELOCITY_DIST=1, VEL_LOW=0.95, VEL_HIGH=1.19/
&EVAC ID='operationteam21', XB=16.0,29.0,3.5,29.0,9.8,11.4, COLOR='BLUE',
     AVATAR_COLOR='BLUE',
     NUMBER_INITIAL_PERSONS=40, PERS_ID='person', MESH_ID='2ndfloorgrid'/

                              ======== THIRD FLOOR EVACUATION =========
&EVAC ID='operationteam31', XB=14.0,26.0,3.0,26.0,15.6,16.8, COLOR='BLUE',
     AVATAR_COLOR='BLUE',
     NUMBER_INITIAL_PERSONS=30, PERS_ID='person', MESH_ID='3rdfloorgrid'/
&EVAC ID='operationteam41', XB=14.0,26.0,3.0,26.0,20.9,22.0, COLOR='BLUE',
     AVATAR_COLOR='BLUE',
     NUMBER_INITIAL_PERSONS=30, PERS_ID='person', MESH_ID='4thfloorgrid'/
13.2,30.9, 2.1,32.1, 20.763,22.0
&SLCF PBX=5.0, QUANTITY='VELOCITY', VECTOR=.TRUE. /
&SLCF PBX=15.0, QUANTITY='VELOCITY', VECTOR=.TRUE. /
&SLCF PBX=199.0, QUANTITY='VELOCITY', VECTOR=.TRUE. /
&SLCF PBY=5.0, QUANTITY='VELOCITY', VECTOR=.TRUE. /
&SLCF PBZ=0.0, QUANTITY='VELOCITY', VECTOR=.TRUE. /

**************************  MAJOR FIRE AREAS  *********************************
&DEVC ID='EVACUATION_ROUTE_1ST_1', XYZ=34.6,8.0,6.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_1ST_2', XYZ=27.0,9.5,6.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_1ST_3', XYZ=19.0,9.5,6.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_1ST_4', XYZ=16.0,8.0,6.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_1ST_5', XYZ=20.0,16.0,6.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_1ST_6', XYZ=15.0,15.0,6.0, QUANTITY= 'TEMPERATURE'/


&DEVC ID='EVACUATION_ROUTE_2ND_1', XYZ=19.0,18.0,10.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_2ND_2', XYZ=18.6,8.0,10.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_2ND_3', XYZ=19.0,24,10.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_2ND_4', XYZ=18.6,13.0,10.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_2ND_5', XYZ=14.0,4.0,10.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_2ND_6', XYZ=6.0,5.0,10.0, QUANTITY= 'TEMPERATURE'/

&DEVC ID='EVACUATION_ROUTE_3RD_1', XYZ=21.4,20.0,16.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_3RD_2', XYZ=17.0,20.0,16.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_3RD_3', XYZ=17.0,10.0,16.0, QUANTITY= 'TEMPERATURE'/

&DEVC ID='EVACUATION_ROUTE_4TH_1', XYZ=15.0,11.0,22.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_4TH_2', XYZ=22.0,8.0,22.0, QUANTITY= 'TEMPERATURE'/
&DEVC ID='EVACUATION_ROUTE_4TH_3', XYZ=14.0,4.0,22.0, QUANTITY= 'TEMPERATURE'/



&VENT MB='XMIN' ,SURF_ID='OPEN' /
&VENT MB='YMIN' ,SURF_ID='OPEN' /
&VENT MB='ZMIN' ,SURF_ID='OPEN' /
&VENT MB='XMAX' ,SURF_ID='OPEN' /
&VENT MB='YMAX' ,SURF_ID='OPEN' /
&VENT MB='ZMAX' ,SURF_ID='OPEN' /

&TAIL /
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