**Question 1**

i) Use the hazard checklist provided in the file named “Q1-Hazard-Checklist-2014.pdf” to identify potential hazards from the Home-Spa steam shower system.

**Solution**: In order to solve this question, there are several characters which relative to risk rank should be analysis firstly. In the analysis process, the hazard severity and probability category would be describe, and form the hazard risk classification to rank hazard risk. The following table 1, table 2 and table 3 represent the process to form risk classification.

● **Hazard Severity Category**

Table 1: Hazard Severity Category

|  |  |
| --- | --- |
| Category Name | Description |
| Catastrophic | Injures or major damage to the multiple people |
| Critical | Injure or major damage to users inside of enclosure, lead to loss of the major system |
| Marginal | Minor injury and significant threat to the service, lead to server system damage |
| Insignificant | Possible minor injury or effect on service, lead to minor system damage |

● **Hazard Probability Category**

Table 2: Hazard Probability Category

|  |  |
| --- | --- |
| Category Name | Description |
| Frequent | Likely to occur frequently, the hazard will be continually experienced |
| Probable | Will occur several times, the hazard can be expected to occur often |
| Occasional | Likely to occur several times. The hazard can be expected to occur several times |
| Remote | Likely to occur sometime in the system lifecycle. The hazard can reasonably be expected to occur |
| Improbable | Unlikely to occur, but possible. It can be assumed that the hazard will exceptionally occur |
| Incredible | Extremely unlikely to occur. It can be assumed that the hazard may not occur |

● **Hazard Risk Classifications**

Table 3: Hazard Risk Classifications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Frequence of occurrence of a hazardous event | Risk Levels | | | |
| Frequent | Undesirable | Intolerable | Intolerable | Intolerable |
| Probable | Tolerable | Undesirable | Intolerable | Intolerable |
| Occasional | Broadly Acceptable | Undesirable | Undesirable | Intolerable |
| Remote | Broadly Acceptable | Tolerable | Undesirable | Undesirable |
| Improbable | Broadly Acceptable | Broadly Acceptable | Tolerable | Tolerable |
| Incredible | Broadly Acceptable | Broadly Acceptable | Broadly Acceptable | Broadly Acceptable |
|  | Catastrophic | Critical | Marginal | Insignificant |

As the result, the hazard risk classification could be divided into 4 levels, there are: A – **Intolerable,** B - **Undesirable**, and tolerable only where the costs of reduction are grossly disproportionate to the improvement gained, C - **Tolerable** if the cost of Reduction would exceed the improvement gained and D - **Broadly Acceptable.**

The following table 4 shows the potential hazards identified by *Hazard-Checklist-2014*.

Table 4: Identified Potential Hazard by Hazard Checklist

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No | Hazard Source Type | Possible Causes | Possible Effects | Risk Rating | Potential Hazard in Case |
| H001 | Toxic Materials | **Gas which can be inhaled** : 1) Outgassing of gasses in confined spaces | 1) Respiratory Stem Blood System, 2) Body Organs, 3) irritation of eyes, nose 4) Nervous System | D | Fragrance system could only control by users without senor to detect the density of fragrance in enclosure or runtime. The long running time of this function could hurt user's health. |
| H002 | Toxic Materials | **Inadequate oxygen for respiration due to**: 1) Insufficient ventilation if occupied, enclosed space | 1) Blood System, 2) Body Organs, 3) Asphyxiation, 4) Reduction in personnel efficiency or capabilities | B | The shower enclosure is a single-piece moulding in acrylic sheeting, which could from a enclosed environment. Then, it could effect on human health. |
| H003 | Toxic Materials | Use of food, cosmetic, or drug that is a carcinogen: 1) Bacteria and viruses | 1) Irritation of eyes, nose, throat, or respiratory passages | A | The water softener have the hazard in long time usage, which could breed Bacteria or viruses in this device, and dispense into enclosure with steam. |
| H004 | Pressure | **Pressure relief failure**: 1) No pressure relief valve or vent 2) Incorrectly installed, incorrectly adjusted, not calibrated. **Low Pressure**: 3) Compressor or pump failure | 1) Container explodes, or Leakage | B | The Fragrance pumped into steam inlet nozzle by a non-return valve, as the result, the Fragrance tank have no opportunity to modify its pressure. Once the non-return valve install in the wrong direction, the system would failure immediately. |
| H005 | Pressure | **Pressure changes**: Changes of temperature | 1) Container explodes, or Leakage | D | The improving temperature could arise the pressure in Fragrance tank increasing, and lead to leakage. |
| No | Hazard Source Type | Possible Causes | Possible Effects | Risk Rating | Potential Hazard in Case |
| H006 | Heat and Temperature | **High Temperature: Generation or absorption of heat from**: 1) Inadequate heat dissipation capacity or cooling system failure | 1) Heat cramps, strokes, and exhaustion 2) Reduced personnel efficiency and errors 3) | D | The temperature sensor in the enclosure have hazard to fail to work, and cannot protect user from hurt from high temperature shower environment. |
| H007 | Explosives and Explosions | **Inadvertent activation by electrical current, heat, electromagnetic radiation, lightning or other static electricity, impact or fire** of 1) Combustible gases in containers or confined spaces | 1) Over-pressures, 2) Container rupture | B | When the Fragrance tank contains the material which is flammable, the tiny spark from control panel or lighting would cause explosion. |
| H008 | Electrical and Electronic | **Short circuits caused by**: 1) Dirt, contamination, or moisture, 2) Corrosion **Accidental contact with live circuit through**: 1) Erroneous connection, 2) Lightning strike | 1) Ignition of combustibles, 2) Surface damage to metals, 3) Interference with electrical equipment operation | B | The environment inside enclosure would moist and high- temperature sometimes, and effects on the performance in control device inside the enclosure. As the result, these devices have the hazard to raise failure because of their working environment. |
| H009 | Vibration and Noise | **Fluid dynamics**: 1) High-velocity fluid hitting a surface or object that can vibrate | 1) Metal fatigue and other changes in crystalline structure 2) Interference with communications | B | The water go through overhead jet and boy jets, could in a considerable velocity to raise noise and vibration in the closed environment in enclosure. This cause problem on structure of shower and effects on the communication with the people inside and outside. |
| H010 | Mechanical Hazards | 1) Impact by moving equipment or part 2) Toppling or overturning of unstable products | 1) Part of body caught in pinch point | C | When moving the door of the enclosure, people would be extruded by the edge between door and sheeting. |
| H011 | Mechanical Hazards | 1) Fall from an elevated position | 1) Bruises and crushed or broken bones 2) Strain | B | The moist environment inside enclosure improve the smooth of moulded seat and shower tray. As the result, there is hazard in people fall down inside the enclosure or fall onto seat. |
| H012 | Mechanical Hazards | 1) Falling objects, covers, or parts | 1) Bruises and crushed or broken bones 2) Cuts, scratches, and puncture wounds | D | The overhead jet have the hazard to fall down from installation position, and cause damage. |
| H013 | Mechanical Hazards | 1) Fall from an elevated position | 1) Bruises and crushed or broken bones 2) Cuts, scratches, and puncture wounds | B | The instalment seat would fall down when people sit on it, and this would raise damage. |
| H014 | Chemical Reactions | 1) Ground moisture 2) Condensation of atmospheric moisture | Material degradation | D | The moisture working environment of metal devices in enclosure could raise material detrition. Contains of fragrance would raise the chemical reactions because of its chemical contains. |
| H015 | Human Factors | 1) Unable to control panel immediately 2) Make mistake on other kinds of control operation | Error or delay in use of controls | D | The lighting function and steam, fragrance function install outside the enclosure, which make user cannot control these function when he inside of enclosure. |

ii) Repeat your hazard identification, this time using Energy Trace and Barrier Analysis. Full checklists of energy types, barrier and energy conversion problems are provided in the file named *Q1-ETBA-Checklist-2014.pdf*.

**Solution**: According to ETBA Procedure, define Home Spa steam shower system energy source is **AC electrical current flows**, at the same time, the **Pressure** from **Current** **Water** and **Fragrance** in shower system could also be one kind of energy in the system which could help system to provide service to users.

First of all, select **electrical flow** as the energy to analysis. The flow **enters** into system by mains power to **Steam Generator** [10], and it will work at **Steam Generator** [10], **Fragrance Pump** [15], **Control Unit** [20], **Control Panel** [17], **Temperature Sensor** [19] and **Lights** [18]. It will **exit** system at **Steam Generator** [10]. The following is the details on define planned barriers to control flows, barrier problems, consider energy converter problems, and effects on targets.

Moreover, select **current water** and **fragrance flow** as **Pressure** to analysis. The flow **enters** into system by Hot supply and Cold supply to **Water Softener** [12] and **Mixer / Selector Valve** [9]. It will work at **Water Softener** [12], **Steam Generator** [10], **Pressure Relief Valve** [13], **Steam Inlet Nozzle** [11], **Mixer / Selector Valve** [9], **Body Jets** [8] and **Overhead Jet** [7]. The flow into system by **Fragrance Tank** [14], it will work in **Fragrance Pump** [15], **Non-Return Valve** [16] and **Steam Inlet Nozzle** [11]. The following is the details on define planned barriers to control flows, barrier problems, consider energy converter problems, and effects on targets.

Furthermore, select gravity of **domed roof**, **moulded seat** and **overhead jet** as **Mass / Gravity / Height** to analysis. This energy enters the system at the component’s working location. The following is the details on define planned barriers to control flows, barrier problems, consider energy converter problems, and effects on targets. The following table 5 is represent the hazard identified by ETBA.

Table 5: Identified Potential Hazard by ETBA

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| No | Pinpoint Energy Input | Planned Barriers | Hazard | Barrier Problems | Valued Target | Risk Rating | Recommended Barriers |
| H001 | Steam Generator | None | electrical shock, power cut or long time running makes device broken | Barrier ineffective | Steam Generator | D | ● install the electrical shock protection device.  ● install Noise Sensor in System find broken. |
| H002 | Control Unit | None | electrical shock, power cut or long time running makes device broken | Barrier ineffective / incorrectly designed | Control Unit | A | ● install the electrical shock protected device or energy storage system to supply power. |
| H003 | Fragrance Pump | None | electrical shock, power cut or long time running makes device broken | Barrier ineffective / incorrectly designed | Fragrance Pump | D | ● install the electrical shock protection device or energy storage system to supply electrical power. |
| No | Pinpoint Energy Input | Planned Barriers | Hazard | Barrier Problems | Valued Target | Risk Rating | Recommended Barriers |
| H004 | Control Panel | None | electrical shock, power cut or long time running makes device broken | Barrier ineffective / incorrectly designed | Control Panel | B | ● install the electrical shock protection device or energy storage system to supply electrical power. |
| H005 | Temperature Sensor | None | electrical shock, power cut or long time running makes device broken | Barrier ineffective / incorrectly designed | Temperature Sensor failure | B | ● install the electrical shock protection device or energy storage system to supply electrical power. |
| H006 | Lights | None | electrical shock, power cut or long time running makes device broken | Barrier ineffective / incorrectly designed | Lights | A | ● install the electrical shock protection device or energy storage system to supply electrical power. |
| H007 | Water Softener | Container to storage overflow water | too much water into softener | Barrier ineffective / incorrectly designed | Water Softener | B | ● install a non-return valve before softener to protect the water softener from damage of too much water flow |
| H008 | Steam Generator | Pressure Relief Valve | Pressure in stream generator device increase when perform faster than design limited | Barrier ineffective / failed completely | Steam Generator | B | ● install a valve before generator to control the water flow based on the left water |
| H009 | Steam Inlet Nozzle | Pressure Relief Valve | Flow / transfer unintended / too much / too little / none at all | Barrier degraded / failed completely | Steam Inlet Nozzle | C | ● install a sensor to estimate the pressure situation inside of channel, then control the speed of steam generating. |
| H010 | Mix / Selector Valve | None | water flow cause the damage the mix/select valve | Barrier degraded / failed completely | user | B | ● install a drain before Mixer / Selector Valve to discharge the overflow water. |
| H011 | Overhead / Body Jets | Jet has limited | water flow cause the damage the overhead body jets limited | Barrier degraded / failed completely | user | A | ● Install a device which could reduce the speed of fluent water down to hurtles speed. |
| H012 | Drain | None | too much water into in the enclosure | Barrier degraded | Enclosure. | D | ● install a sensor which could monitor the height level of water in enclosure, to control the input water speed. |
| H012 | Fragrance Pump | None | no fragrance in the tank, and cause pump no material to perform | Barrier degraded | fragrance tank | B | ● install a sensor to estimate the left fragrance in the fragrance tank to advise user to add material. |
| H013 | Overhead Jet | Support device | Support broken | Barrier too strong / weak | user or material | A | ● Install extra support devices |
| H014 | Moulded Seat | Support device | Support broken | Barrier too strong / weak | user or material | A | ● Install extra support devices |
| H015 | Domed Roof | Acrylic sheeting and Frame | Support broken | Barrier too strong / weak | user or material | A | ● Install extra support devices |

iii) Compare and comment on your results from parts (i) and (ii), considering (at least) the effectiveness of the techniques, their ease (or otherwise) of application and effort required.

**Solution**: For the result from part (i), the Q1-Hazard-Checklist-2014 provides the guidance to analysis the potential hazard in system by **causes** and **effects**. These threaten features in the work system would cause accident in the operation. This analysis is a systematic evaluation in **root cause** by pre-established standard. In the result of analysis, it includes **equipment issues** and **human factors issues**, and **conformance** and **non-conformance determinations**. As the result, analysis requires **balancing** of **technical definition** of hazard against need for sensible action/tracking, and would **contribute** to all kinds of area’s safety management. This technique also takes care of **critical human errors** and **hardware failures** which is better the ETBA analysis. **However**, it **cannot** identify the hazard which caused by the energy conversation or release. For hazard identification **application** by generically checklist, it requires the users to analysis the root cause of hazard with equipment issues. As a result, this is **not** an **easy progress** in the system with many different or newly techniques. This activity requires the users or experts have the **background knowledge** or **experience** on this industry area. In the other words, the analysis’s **effort** could be effect by the experts’ abilities or training.

For the result from part (ii), the Q2-ETBA-Checklist-2014 provides the guidance to analysis the hazard in system by uncontrolled **energy conversation** or **release**, and energy effect on **vulnerable target**. These conversations would raise the problem which leads to unintended harm. Energy Trace and Barrier Analysis determines the effectiveness of countermeasures employed or proposed to mitigate the risk induced by energy conversation. As the result, this analysis could use **family** of **similar** **techniques**, and perform well in multiply energy source system or product. It is a **powerful** and **efficient** approach in discovery hazard associated with energy sources. Furthermore, its procedures produce **consistent, reasoned and objective judgements** on hazards. **However**, it will **miss** the hazard un-relative to energy source. For the **application** of ETBA, it requires the users or expert to have the **logically** way in operation in identify hazard. Fortunately, it provides a detailed procedure in analysis, which could make **user** **without** long time **training** or **experience** to perform well. However, the result’s **effort** relative to the procedure’s repeat situation and quality of procedures. In the other word, the effort of analysis depend on the user whether to perform process as guidance.

iv) Carry out a HAZOP study of the steam shower system.

In the Home Spa steam shower system, there are four flows includes electrical flow, hot water flow, cold water flow, and fragrance flow. Firstly of all, analysis the electrical flow by hazard and operability studies in the follow table 6.

Table 6: HAZOP

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Guide Word | Deviation | Possible Causes | Consequences | Action Required |
| No or None | No flow | 1. No electrical supply by Power Company 2. Mains power broken 3. Fuse in power supply melt because of devices short circuit | 1. Steam cannot created in Steam Generator. 2. Air cannot be pumped into Fragrance system in Fragrance pump 3. The Control Unit cannot work 4. Temperature senor cannot monitor within enclosure 5. Control Panel cannot work 6. Lights cannot work | 1. Install an electrical device, like uninterruptible power supply in the system 2. Install alarm light and speaker with battery to monitor loss of the electrical supply 3. Connect to this system with more than one Main Power which have different fuse protection system in house 3. Provide the guidance in installation of Home Spa System to make sure system not connect to undersigned power system |
| More | More flow | 1. Thunder shock on the electrical supply system 2. Transformer cannot work cause the high-voltage electrical flow supply to the system 3. Other unknown high-voltage electrical flow connect to system | 1. Steam Generator burnout 2. Fragrance Pump burnout 3. Control Unit cannot work or burnout 4. Control Panel cannot work burnout 5. Temperature Senor burnout 6. Lights become brighter or burnout | 1. Install a device in main power to broken down connection to system when monitor the high-voltage electrical flow 2. Install alarm light and speak with battery to monitor voltage which higher than designed voltage 3. Install a device in Control Panel to stable the input voltage 4. Install a device in Lights to monitor high-voltage power, broken the power supply 5. Install a power system could provide designed voltage flow, and replace original power system when facing fault 6. Provide the guidance in installation of Home Spa System to make sure system not connect to undersigned power system |
| Less | Less flow | 1. Transformer have problem in transform voltage and supply the low-voltage flow (A.C) 2. Power supply system provide the less voltage electrical flow (D.C) | 1. Steam Generator cannot operate as designed speed, and cannot produce as much steam as user wish 2. Fragrance Pump cannot pump the enough air into the Fragrance system 3. Control Unit, Control Panel, Temperature Sensor cannot work 4. Lights cannot provide the designed lighting | 1. Install a power supply system which could increase voltage in main power to avoid the damage caused by low voltage work environment 2. Install a battery connect to Control Unit, Control Panel and Temperature Sensor to make sure these devices work |
| More than or As well as | more little flow or as well as flow | 1. Transformer have problem in transform voltage to the designed voltage (A.C) 2. Power supplier provides the flow with higher than system designed voltage | 1. Steam Generator operators faster than design speed 2. Fragrance Pump operators faster than design speed 3. Control Unit, Control Panel would damage because the higher voltage than their designed | 1. Install a device to modify the voltage reduce the normal voltage flow 2. Install a power supply system which could provide designed voltage electrical flow and supply power when monitor the high voltage flow has been provided by original power system 3. Provide the guidance in installation of Home Spa System to make sure system not connect to undersigned power system |
| Guide Word | Deviation | Possible Causes | Consequences | Action Required |
| Part of | Less flow | 1. Transformer have problem in transform voltage and supply the low-voltage flow (A.C) 2. Power supply system provide the less voltage electrical flow (D.C) | 1. Steam Generator cannot operate as designed speed, and cannot produce as much steam as user wish 2. Fragrance Pump cannot pump the enough air into the Fragrance system 3. Control Unit, Control Panel, Temperature Sensor cannot work 4. Lights cannot provide the designed lighting | 1. Install a power supply system which could increase voltage in main power to avoid the damage caused by low voltage work environment 2. Install a battery connect to Control Unit, Control Panel and Temperature Sensor to make sure these devices work |
| Other than | Flow in undersigned component | 1. Operation Component broken cause leakage 2. Main Power broken cause leakage 3. Unintended power system connect to Home Spa System cause flow | 1. Electrical Flow may contain in water supply system 2. Mattel component or other kinds of electric conduction materials have electrical flow 3. Fragrance System contain electrical flow | 1. Install a sensor to estimate the voltage situation in the component which undersigned to contain electricity 2. Install alarm system to remind user when get the leakage information from sensor 3. Provide the guidance in installation of Home Spa System to make sure system not connect to undersigned power system |
| Reverse | Reverse Flow | 1. The wrong connect in socket 2. The wrong flow direction has been supplied in power supply system (D.C) | (if the Home Spa System work in Alternating Current environment, this situation would not cause problem) 1. Devices which require electrical supply cannot work | 1. Install the devices which could transform Direct Current entry system in the right direction 2. Attached a notation on the socket to make sure connection is correctly 3. Change the Home Spa System electrical supply to Alternating Current |

For this problem, there are other three flow which are hot water flow, cold water flow and frequency flow has been omission in the description. For these three flows, they all have the same guide word: no or none, other than, more, less, more than or as usual part of and reverse. These three flows are **liquid flow**, which would be effect by the **gravity**. As the result, the liquid may left on some component of system when facing the flow less than normal situation. These problems should be considered and take actions.