**Flammable Liquid “What-If” Example**

| **Department: Chemistry** | **Description of Operation:****Use of stirring hotplate with flammable liquid** | **By:****Review Team Date:** |
| --- | --- | --- |
| **WHAT IF?** | **ANSWER** | **PROBABILITY** | **CONSEQUENCES** | **RECOMMENDATIONS** |
| Used on unventilated benchtop | Flammable vapors could accumulate and reach source of ignition causing fire | High | Extensive damage/downtime and costs | Use in fume hood |
| Overexposure to toxic vapors | High | Adverse health effects | Use in fume hood |
| Mechanical failure of fume hood exhaust fan | Lack of exhaust but vapors still accumulate and ignition sources still present | Moderate | Adverse health effects | Interlock hotplate power to exhaust monitor |
| Fire | Moderate | Damage | Use explosion proof hotplate |
| Power failure during use (see also loss of heat and loss of stirring below) | Lack of exhaust, vapors may accumulate but at lesser magnitude, potential fire | Very high | Damage/health effects | Connect exhaust fan to emergency power |
| Reaction becomes unstable | Very high | Failed experiment, exposure to unknown products | Conduct a review of all possible reactions and outcomes |
| Hotplate malfunction, electrical arcing (switch/ thermostat) | Possible fire in hotplate and ignition of solvent vapors | Moderate | Equipment damage/personnel injuries | Check electrical connections (plugs and wires); pretest hotplate before starting; use explosion proof hotplate |
| Hotplate malfunction, supplies too much heat | Heat material above flash point | Moderate | Fire, damage, personnel injuries | Interlock hotplate to temperature feedback loop |
| Reaction becomes unstable | Moderate | Personnel injuries | Do not leave reaction unattended; check temperature of reaction at regular intervals |
| Unintended reaction occurs | Moderate | Hazardous byproducts | Conduct a review of all possible reactions and outcomes |
| Hotplate malfunction; supplies too little heat; if no heat, see loss of power above | Reaction unsuccessful | Moderate | Lost time and materials | Interlock hotplate to temperature feedback loop |
| Reactants degrade/ evaporate | Moderate | Lost time and materials; hazardous byproducts | Do not leave reaction unattended; check temperature of reaction at regular intervals |
| Loss of Stirring | Superheating of portion of flask contents | Very high | Vessel fails/fire | Interlock hotplate to temperature feedback loop |
| Unintended reaction occurs | High | Hazardous byproducts | Conduct a review of all possible reactions and outcomes |
| Loss of Stirring (cont) | Reaction unsuccessful | High | Lost time and materials | Do not leave reaction unattended; check temperature and stirring of reaction at regular intervals |
| Flash fire | High | Fire/damage/ personnel injuries | Do not handle hot vessel |
| Spill from container being heated | Reaction unsuccessful | High | Lost time and materials | Do not leave reaction unattended |
| Open container boils dry | High | Failed reaction | Connect hotplate to timer and temperature feedback loop |
| Heating period is too long | Vessel breaks | High | Vessel fails/fire | See above |
| Reaction unsuccessful | High | Lost time and materials | Do not leave reaction unattended |
| Unreacted starting material | High | Hazardous byproducts | Connect hotplate to timer and temperature feedback loop |
| Heat period is too short | Unstable products | High | Personnel injuries | Conduct a review of all possible reactions and outcomes |
| Reaction unsuccessful | High | Lost time and materials | Do not leave reaction unattended |
| Flash fire | High | Fire/damage/ personnel injuries | Check container for signs of prior damage or use new container |
| Container breaks | Vessel breaks | High | Fire/Damage/ personnel injuries | Do not use a closed container; use container with a pressure relief device |
| Residual process gas in equipment when opened | Vessel cannot be opened | High | Lost time and materials | See above |
| Unintended reaction occurs | High | Hazardous byproducts | Conduct a review of all possible reactions and outcomes |

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**Hazardous Gas Example**

| **Department: Chemistry** | **Description of Operation:****Use of toxic or flammable gas in small cylinder in fume hood** | **By:****Review Team Date:** |
| --- | --- | --- |
| **WHAT IF?** | **ANSWER** | **PROBABILITY** | **CONSEQUENCES** | **RECOMMENDATIONS** |
| Power to exhaust fan is lost | Possible exposure to toxic gas if gas flow conwintues | Very high | Serious | Provide emergency power and normally closed gas valve |
| Mechanical failure of exhaust fan | Same as above | Moderate | Serious | Same as above and consider using redundant fans |
| Regulator fails or creeps and allows full cylinder pressure to apparatus | Apparatus or tubing failure and gas release if not able to handle full cylinder pressure | Low | Serious | Use flow restricting orifice in cylinder valve |
| Cylinder regulator gauge blows | High pressure gas release and possible exposure | Low | Serious | Same as above |
| Gas leak downstream of regulator; hood face at 18 inches | Lower pressure gas release but potential exposure which increases with gas flow rate | Moderate | Serious | Same as above |
| Gas leak downstream of regulator; hood face at 30 inches with operator at hood | Same as above but high potential for exposure | Moderate | Serious | Same as above and restrict hood opening while gas flowing via interlock, or stop and consider use of a self- contained breathing apparatus (SCBA) if access during flow is necessary |
| Cylinder contains wrong contents | Potential exothermic reaction or if not, ruined experiment and apparatus | Low | Serious | Check cylinder tag, not just cylinder stencil |
| Cylinder pressure is incorrect | Regulator gauge could fail; rapid release of high pressure gas | Low | Serious | Same as above  |
| Apparatus contains oxygen when gas is introduced | Explosion potential if gas hits flammable range and ignition source is present | Moderate | Serious | Assure purge with inert gas before introducing flammable gas if ignition source may be present (consider automation) |
| Residual process gas in equipment when opened | Potential exposure to toxic gas | Moderate | Serious | Same as above; test atmosphere or use SCBA |

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