| OWNER: | PARS PETROCHEMICAL COMPANY | | | | | | CONTRACTOR/Sub-Contractor: |
|---|---|---|---|---|---|---|---|
| | PROPANE DEHYDROGENATION (PDH) PROJECT | | | | | | |
| MC : | Description Of Process Emergency Conditions For Process Units | | | | | | |
| | Project Code | Sec | Phase Code | Department | Doc. Type | Serial No. | |
| Document Number: | 3981-00-BA-PR-PDS-028 | | | | | | Rev.: 01 / Page: 1 of 68 |

# Description Of Process Emergency Conditions For Process Units

| | | | | | |
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| 01 | 16-Jun-2025 | Approved For Design | LC | ZGC | YGH |
| 00 | 19-May-2025 | Issued For Comment | LC | ZGC | YGH |
| **Rev.** | **Date** | **Purpose of Issue** | **Prepared** | **Checked** | **Approved** |
| | | | | | **Class: 2** |

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## TABULATION OF REVISED PAGES

| Page | Revision | | | | | | | | Page | Revision | | | | | | | | Page | Revision | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
| 1 | ✓ | ✓ | | | | | | | 37 | ✓ | | | | | | | | 73 | ✓ | | | | | | | |
| 2 | ✓ | | | | | | | | 38 | ✓ | | | | | | | | 74 | ✓ | | | | | | | |
| 3 | ✓ | | | | | | | | 39 | ✓ | | | | | | | | 75 | ✓ | | | | | | | |
| 4 | ✓ | | | | | | | | 40 | ✓ | | | | | | | | 76 | ✓ | | | | | | | |
| 5 | ✓ | | | | | | | | 41 | ✓ | | | | | | | | 77 | ✓ | | | | | | | |
| 6 | ✓ | | | | | | | | 42 | ✓ | | | | | | | | 78 | | | | | | | | |
| 7 | ✓ | | | | | | | | 43 | ✓ | ✓ | | | | | | | 79 | | | | | | | | |
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| 12 | ✓ | | | | | | | | 48 | ✓ | | | | | | | | 84 | | | | | | | | |
| 13 | ✓ | | | | | | | | 49 | ✓ | | | | | | | | 85 | | | | | | | | |
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| 16 | ✓ | | | | | | | | 52 | ✓ | ✓ | | | | | | | 88 | | | | | | | | |
| 17 | ✓ | | | | | | | | 53 | ✓ | ✓ | | | | | | | 89 | | | | | | | | |
| 18 | ✓ | | | | | | | | 54 | ✓ | ✓ | | | | | | | 90 | | | | | | | | |
| 19 | ✓ | | | | | | | | 55 | ✓ | ✓ | | | | | | | 91 | | | | | | | | |
| 20 | ✓ | | | | | | | | 56 | ✓ | | | | | | | | 92 | | | | | | | | |
| 21 | ✓ | | | | | | | | 57 | ✓ | | | | | | | | 93 | | | | | | | | |
| 22 | ✓ | | | | | | | | 58 | ✓ | | | | | | | | 94 | | | | | | | | |
| 23 | ✓ | | | | | | | | 59 | ✓ | ✓ | | | | | | | 95 | | | | | | | | |
| 24 | ✓ | | | | | | | | 60 | ✓ | | | | | | | | 96 | | | | | | | | |
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| 30 | ✓ | | | | | | | | 66 | ✓ | | | | | | | | 102 | | | | | | | | |
| 31 | ✓ | | | | | | | | 67 | ✓ | | | | | | | | 103 | | | | | | | | |
| 32 | ✓ | | | | | | | | 68 | ✓ | | | | | | | | 104 | | | | | | | | |
| 33 | ✓ | | | | | | | | 69 | ✓ | | | | | | | | 105 | | | | | | | | |
| 34 | ✓ | | | | | | | | 70 | ✓ | | | | | | | | 106 | | | | | | | | |
| 35 | ✓ | | | | | | | | 71 | ✓ | | | | | | | | 107 | | | | | | | | |
| 36 | ✓ | | | | | | | | 72 | ✓ | | | | | | | | 108 | | | | | | | | |

# TABLE OF CONTENTS


1. Introduction 5

1.1. Terms and Definitions 5
1.2 Scope of Document 7
1.3 Document Usage 7

2. General Emergency Response Procedures 8

2.1 Emergency Response Organization 8
2.2 Alarm Response 8
2.3 Emergency Classification 8
2.4 Communications 9
2.5 Documentation 9

3. Process Description Overview 10

3.1 Feed Preparation Section 10
3.2 Reaction Section 10
3.3 Catalyst Regeneration System 10
3.4 Utility System 11

4. Critical Process Parameters 11

4.1 Temperature Parameters 11
4.2 Pressure Parameters 12
4.3 Flow Parameters 12
4.4 Composition Parameters 13

5. Feed Preparation Section Emergencies 13

5.1 Feed Pump Failure 13
5.2 Feed Preheater Temperature Excursion 14

6. Reaction Section Emergencies 16

6.1 Reactor Temperature Excursion 16
6.2 Loss of Reactor Flow 17
6.3 Reactor Pressure Excursion 19
6.4 Reaction Runaway 21

7. Product Recovery Section Emergencies 22

7.1 Compressor Emergency 22
7.2 Column Flooding 25
7.3 Reboiler Failure 27
7.4 Reflux System Failure 28
7.5 Product Quality Excursion 30

8. Utilities Failure Scenarios 32

8.1 Cooling Water System Failure 32
8.2 Steam System Failure 34
8.3 Electrical Power Failure 36

8.4 Instrument Air Failure 38
8.5 Nitrogen System Failure 40
9. Environmental Release Scenarios 42
9.1 Flammable Gas Release 42
9.2 Liquid Hydrocarbon Release 44
9.3 Acid/Caustic Release 47
9.4 Release to Flare System 49
~~10. Deleted~~ 51
11. Safety Relief Scenarios 51
11.1 Process Vessel Relief 51
~~11.2 Deleted~~ 53
~~11.3 Deleted~~ 53
11.4 Flare System Overload 54
12. Startup And Shutdown Risks 56
12.1 Plant Startup Hazards 56
12.2 Planned Shutdown Hazards 58
12.3 Catalyst Handling Hazards 60
13. Post-Emergency Recovery 61
13.1 Post-Emergency Assessment 61
13.2 Equipment Restart Requirements 63
13.3 Incident Investigation 65
13.4 Regulatory Reporting 66
14. References 68

# 1. Introduction

**Pars Petrochemical Company** intends to build a propane Dehydrogenation (PDH) plant to produce 600 KTY propylene based on UOP Oleflex technology in Pars south economic energy zone (PSEEZ), Asalouyeh , Bushehr Province, Iran.

EPCC contractor for PDH plant: Panah Sanat Part Co., and BINA Co. Consortium.

The plant consists of several main process units, including Feed Treatment, Dehydrogenation reactor CCR, Distillation, Hydrogenation reactor, refrigeration, Merox, utility, tankage, …

## 1.1. Terms and Definitions

| | |
|---|---|
| PROJECT: | Propane Dehydrogenation Plant (PDH) |
| Contract Number: | 39-402/685 |
| OWNER: | Pars Petrochemical Company |
| MC: | Aria Pishro Gharn |
| CONTRACTOR: | Panah Sanat Part and BINA CO. Consortium |
| PDP | Based On UOP Oleflex Technology |
| BASIC DESIGNER: | Sinowey Company |
| SITE: | Pars south economic energy zone (PSEEZ), Asalouyeh Bushehr Province, Iran. |
| SUBCONTRACTOR: | Organization/Party that CONTRACTOR hires to complete the WORK |
| GOODS: | Any and all equipment machinery, apparatus, material, and other PROJECT commodity described in the contractor's contract. |
| VENDOR: | Any manufacture/supplier selected by OWNER/CONTRACTOR to supply the GOODS |

| | |
|---|---|
| MANUFACTURER: | Any manufacture/supplier selected by OWNER/CONTRACTOR to supply the GOODS |
| **Shall**: | Indicates mandatory requirements to be strictly followed. |
| **Should:** | Indicates that through several possibilities, one is recommended as practically suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required. Other possibilities may be applied subject to OWNER approval. |
| **May:** | It is used where a provision is completely discretionary |
| **Emergency Condition:** | An abnormal process situation that poses an immediate risk to personnel, equipment, environment, or production, requiring prompt action outside normal operating procedures. |
| **Critical Process Parameter:** | A process variable that, if not maintained within safe limits, could lead to a hazardous condition. |
| **Safety Instrumented System (SIS):** | An independent control system designed to automatically take a process to a safe state when predetermined conditions are violated. |
| **Emergency Shutdown (ESD):** | A system designed to minimize the consequences of an emergency by quickly and safely shutting down the process. |
| **Layer of Protection:** | Independent safeguards that prevent or mitigate the effects of process hazards. |

**Safe Operating Limits:** The upper and lower limits for process parameters that define the envelope within which the plant can be safely operated.

## 1.2 Scope of Document

This document covers process emergency conditions for all major units of the PDH plant:

- Feed Preparation Section
- Reaction Section
- Catalyst Regeneration System
- Product Recovery Section
- Utility Systems directly supporting the PDH process

The document addresses emergencies originating from:

- Process deviations
- Equipment failures
- Loss of utilities
- External events affecting process safety
- Human errors
- Material releases

## 1.3 Document Usage

This document should be used for:

- Training operations personnel on emergency recognition and response
- Developing and updating emergency operating procedures
- Conducting emergency drills and tabletop exercises
- Analyzing and investigating process incidents
- Reviewing process safety systems and safeguards
- Supporting management of change evaluations

# 2. General Emergency Response Procedures

## 2.1 Emergency Response Organization

The plant emergency response organization consists of:

- **Emergency Director**: Overall responsibility for managing emergencies
- **Incident Commander**: Field coordination of emergency response activities
- **Operations Team**: Process monitoring and control actions
- **Emergency Response Team**: Tactical response including firefighting and rescue
- **Technical Support Team**: Process expertise and troubleshooting
- **Medical Response Team**: First aid and medical assistance
- **Security Team**: Access control and evacuation coordination

During emergencies, the control room serves as the Emergency Control Center unless relocation is necessary.

## 2.2 Alarm Response

Alarm response follows a standardized approach:

1. Acknowledge the alarm
2. Analyze the situation (identify the cause and potential consequences)
3. Act on the alarm (take corrective action, escalate if required)
4. Assess the effectiveness of actions taken
5. Advance to normalization once the emergency is controlled

All emergency alarms are specified in 3981-00-BA-PR-LST-015 Alarm & Trip Set Points List.

## 2.3 Emergency Classification

Emergencies are classified into three levels:

**Level 1 (Alert):**

- Minor process deviations requiring operator attention
- No immediate risk to personnel or equipment

- Contained within a small area
- Can be handled by operators using normal procedures

**Level 2 (Plant Emergency):**

- Significant process deviation or equipment failure
- Potential risk to personnel within the unit
- May require partial unit shutdown
- Requires emergency response team activation
- May involve minor material releases

**Level 3 (Facility Emergency):**

- Severe process deviation or major equipment failure
- Significant risk to personnel and/or equipment
- Requires full or multiple unit shutdown
- Requires full emergency response organization
- May impact areas outside the process unit
- May involve significant material releases

## 2.4 Communications

Emergency communications use the following channels:

- Plant radio system (primary)
- Plant telephone system (secondary)
- Public address system (for evacuation and general announcements)
- Manual alarms (fire alarms, gas detection alarms)
- Emergency air horns (as backup)

Communications between field personnel and the control room are maintained throughout emergency situations.

## 2.5 Documentation

All emergency events are documented in:

- Control room log
- Emergency response report
- Incident investigation report (for Level 2 and 3 events)
- Lessons learned database
- Management of change (if system modifications result)

## 3. Process Description Overview

To understand emergency conditions, a basic understanding of the PDH process is necessary. The UOP Oleflex™ process consists of several integrated sections:

### 3.1 Feed Preparation Section

Propane feed undergoes treatment to remove contaminants that could poison the catalyst:

- Sulfur compounds removal via adsorbent beds
- Feed drying using molecular sieve beds
- Feed preheating through heat integration with process streams

### 3.2 Reaction Section

The core of the process consists of:

- Multiple Moving-Bed reactors in series (4 reactors)
- Interstage heating using fired heaters
- Proprietary platinum-based catalyst
- Endothermic dehydrogenation reaction ($C_3H_8 \rightarrow C_3H_6 + H_2$)
- Operating temperature: 595-629°C
- Operating pressure: 1-3 bar absolute
- Once-through conversion: 30-35%
- Propylene selectivity: ~85%

### 3.3 Catalyst Regeneration System

The Continuous Catalyst Regeneration (CCR) system maintains catalyst activity by:

- Continuous withdrawal of catalyst from reactors
- Catalyst transport to regeneration vessel
- Coke removal via controlled combustion (477-605°C)
- Catalyst reactivation
- Return of regenerated catalyst to reactors

### 3.4 Utility System

Critical utility systems supporting the process include:

- Cooling water system
- Steam system (multiple pressure levels)
- Instrument air system
- Nitrogen system
- Fuel gas system
- Electrical power distribution
- Flare system

## 4. Critical Process Parameters

Several process parameters are critical to safe operation of the PDH plant. Deviation from safe operating limits for these parameters can lead to emergency conditions.

### 4.1 Temperature Parameters

| Parameter | Normal Operating Range | Alert Limit | Emergency Limit | Consequence of Deviation |
|---|---|---|---|---|
| Reactor Inlet Temperature | 615-634°C | 660°C | / | High: Catalyst damage, reduced selectivity |
| Regenerator Temperature | 477-581°C | 590 | By CRCS | Low: Incomplete regeneration< >High: Catalyst damage, metal dusting |

| | | | | |
|---|---|---|---|---|
| Compressor Discharge Temp | 141-142°C | 175°C | 200°C | Low: Liquid formation< >High: Material limits exceeded |
| Deethanizer Bottom Temp | 51°C | 61°C | / | High: Excessive pressure |
| C3 Splitter Temperature Profile | See operating procedures | ±5°C from profile | ±10°C from profile | Disruption of separation, off-spec product |

## 4.2 Pressure Parameters

| Parameter | Normal Operating Range | Alert Limit | Emergency Limit | Consequence of Deviation |
|---|---|---|---|---|
| Deethanizer Pressure | 2.87 Mpag | 3.2 Mpag | 3.3 Mpag | Low: Poor separation< >High: Potential relief |
| C3 Splitter Pressure | 0.68 Mpag | 0.75Mpag | / | High: Potential relief |
| Fuel Gas Pressure | By vendor | 0.01-0.018 Mpag | / | Low: Burner instability< >High: Over-firing |

## 4.3 Flow Parameters

| Parameter | Normal Operating Range | Alert Limit | Emergency Limit | Consequence of Deviation |
|---|---|---|---|---|
| Fresh Feed Rate | 88292kg/h | 48000kg/h | / | Low: Reduced production |
| Steam Flow to Reboilers | DD specific | ±10% of target | ±20% of target | Low: Poor separation< >High: Entrainment, flooding |

## 4.4 Composition Parameters

| Parameter | Normal Operating Range | Alert Limit | Emergency Limit | Consequence of Deviation |
|---|---|---|---|---|
| Feed Sulfur Content | <30 ppm | / | / | Catalyst poisoning |
| Feed Moisture Content | <1 ppm | Field to Set | Field to Set | Catalyst deactivation |
| Hydrogen in Recycle | H2/HCBN：0.45 | / | / | Process inefficiency |
| Propylene Product Purity | >99.5% | 99.3-99.5% | <99.3% | Off-spec product |
| Chloride Level | CRCS specific | ±20% of target | ±40% of target | Catalyst performance |

# 5. Feed Preparation Section Emergencies

## 5.1 Feed Pump Failure

**Description:** Loss of feed pumping capacity resulting in insufficient feed to the process.

**Potential Causes:**

- Mechanical failure (bearings, seals, impeller)
- Loss of power to pump motor
- Cavitation due to low suction pressure
- Control system failure
- Suction strainer plugging
- Motor overheating

**Consequences:**

- Reduced or complete loss of plant feed
- Potential reactor temperature excursions (if feed stops suddenly)
- Regenerator/reactor catalyst flow imbalance

- Economic losses due to production interruption

**Detection Methods:**

- Low flow alarm on feed flow
- Low discharge pressure alarm
- Pump vibration monitors
- Motor current deviation
- Low reactor feed flow alarms

**Automatic Actions:**

- Automatic startup of standby pump
- Feed forward signal to reactor heaters to reduce firing
- Low flow alarm to operators

**Required Operator Actions:**

- Confirm standby pump operation (if automatic transfer fails)
- Reduce heater firing rates to match reduced feed
- Stabilize catalyst circulation system
- Verify product recovery system adjusts to reduced throughput
- If feed cannot be restored promptly, initiate controlled shutdown

**Prevention Measures:**

- Redundant feed pumps (2×100%)
- Regular preventive maintenance program
- Monitoring of pump performance trends
- Adequate NPSH margin in design
- Motor protection systems

## 5.2 Feed Preheater Temperature Excursion

**Description:** Abnormal temperature in the feed preheating system, resulting in feed entering the reaction section at incorrect temperature.

**Potential Causes:**

- Fouling in heat exchangers
- Control valve failure
- Excessive firing in furnace
- Loss of flow control
- Instrument malfunction
- Steam system issues (for steam-heated exchangers)

**Consequences:**

- High temperature: Premature cracking in preheat system, coking
- Low temperature: Insufficient reaction temperature, reduced conversion
- Accelerated fouling of equipment
- Potential tube rupture in extreme cases

**Detection Methods:**

- High temperature alarms
- Pressure monitoring across exchangers
- Furnace outlet temperature monitoring
- Temperature ratio monitoring

**Automatic Actions:**

- High temperature alarm
- Automatic reduction in furnace firing

**Required Operator Actions:**

1. For high temperature:
   - Reduce heat input (furnace firing)
   - Increase feed rate if possible
2. For low temperature:
   - Check for flow restrictions or valve issues
   - Increase heat input within equipment constraints

- Reduce feed rate if required to maintain quality

3. For both cases:

- Monitor downstream effects on reactor system
- Check for signs of coking or fouling
- Prepare for feed composition adjustments

**Prevention Measures:**

- Regular cleaning and inspection of heat exchangers
- Redundant temperature transmitters
- Regular calibration of control instruments
- Heat balance monitoring

# 6. Reaction Section Emergencies

## 6.1 Reactor Temperature Excursion

**Description:** Abnormally high temperatures in the reactor system, potentially leading to catalyst damage, reduced selectivity, and accelerated side reactions.

**Potential Causes:**

- Excessive feed preheating
- Heater control failure
- Low feed flow with continued heating
- Coke formation causing hot spots
- Catalyst activity variation
- Instrument failure (false readings)

**Consequences:**

- Catalyst sintering and permanent deactivation
- Reduced selectivity (more side reactions)
- Accelerated coke formation
- Potential metal dusting (carbide corrosion)

- Refractory damage
- Potential equipment mechanical damage
- In extreme cases, tube/vessel failure

**Detection Methods:**

- Multiple temperature monitoring points below reactor beds
- Reactor inlet temperature alarms
- Temperature rate-of-change monitoring
- Product composition analysis
- Temperature drop monitoring

**Automatic Actions:**

- High temperature alarms
- Automatic reduction in heater firing rates
- Emergency feed reduction

**Required Operator Actions:**

- Immediately reduce or cut heater firing
- Increase feed rate (if possible) to absorb heat
- Increase catalyst circulation rate (if available)
- Monitor pressure drop for signs of accelerated coking
- Check all instrumentation for false readings

**Prevention Measures:**

- Multiple temperature monitoring points
- Automatic control systems with feed-forward from upstream parameters
- Regular catalyst activity testing
- Conservative operating limits
- Regular heater tuning and maintenance

## 6.2 Loss of Reactor Flow

**Description:** Significant reduction or complete loss of process flow through one or more reactors.

**Potential Causes:**

- Feed system failure
- Control valve failure (closure)
- Blockage due to catalyst, coke, or foreign material
- Instrument failure causing false flow reading
- Severe pressure drop increase
- Upstream equipment trip

**Consequences:**

- Potential temperature excursion due to heat input without cooling flow
- Catalyst overheating and damage
- Coking and fouling
- Mechanical stress from thermal shock when flow resumes
- Reduced or lost production

**Detection Methods:**

- Low flow alarms
- Pressure differential changes across reactors
- Abnormal temperature profiles
- Compressor suction pressure decrease
- Valve position indicators

**Automatic Actions:**

- Low flow alarms
- Automatic heater firing reduction
- Feed forward signals to downstream equipment
- Reactor ESD activation in severe cases

**Required Operator Actions:**

- Immediately reduce or shut down heater firing
- Verify flow measurement with multiple indicators
- Check for valve positioning issues
- Investigate potential blockages
- Prepare for controlled shutdown if flow cannot be restored
- Monitor reactor temperatures during recovery
- If restoring flow, do so gradually to prevent thermal shock

**Prevention Measures:**

- Multiple flow monitoring devices
- Regular inspection for potential flow restrictions
- Catalyst management procedures to prevent migration
- Valve maintenance program
- Heater interlock systems
- Foreign material exclusion procedures

## 6.3 Reactor Pressure Excursion

**Description:** Abnormal pressure in the reactor system, either too high (overpressure) or too low (vacuum).

**Potential Causes:**

- High pressure:
  - Downstream restriction or blockage
  - Control valve failure
  - Relief system issues
  - Compressor issues
- Low pressure:
  - Leak or rupture
  - Control valve failure
  - Condenser issues

**Consequences:**

- High pressure:
  - Reduced catalyst performance
  - Potential equipment damage
  - Relief valve activation
  - Unplanned material release
- Low pressure:
  - Air ingress (potential explosive mixture)
  - Reduced throughput
  - Catalyst flow disturbances
  - Potential vessel collapse (in extreme vacuum)

**Detection Methods:**

- Pressure transmitters with high/low alarms
- Differential pressure monitoring
- pressure relationship monitoring

**Automatic Actions:**

- High/low pressure alarms
- Automatic pressure control adjustments
- Relief valve opening at set pressure

**Required Operator Actions:**

1. For high pressure:
   - Identify and address downstream restrictions
   - Check control valve operation
   - Reduce feed rate if necessary
   - Prepare for controlled depressuring if pressure continues to rise
2. For low pressure:
   - Check for leaks or ruptures

- Verify downstream equipment operation
- Adjust control valves to maintain minimum pressure
- Introduce nitrogen if vacuum risk exists

3. For both cases:
   - Monitor impact on catalyst system
   - Verify all pressure indicators for consistency
   - Adjust heating to accommodate pressure changes

**Prevention Measures:**

- Regular equipment inspection
- Pressure safety valve maintenance
- Control valve maintenance program
- Multiple pressure monitoring points
- Pressure control loops with appropriate tuning
- Relief system design and maintenance

## 6.4 Reaction Runaway

**Description:** Uncontrolled acceleration of the selective hydrogenation reaction， leading to rapid temperature increase and potential equipment damage.

**Potential Causes:**

- Loss of temperature control
- Control system failure
- Abnormal feed composition

**Consequences:**

- Extreme temperature excursions
- Accelerated catalyst deactivation
- Potential equipment damage from thermal stress
- Pressure relief system activation
- Potential fire or explosion if containment is lost

**Detection Methods:**

- Rapid temperature rise alarms
- Temperature profile abnormalities
- Unexpected conversion rate changes
- Product composition changes
- Multiple temperature indicators in reactor beds

**Automatic Actions:**

- High temperature alarms
- Emergency feed reduction or cutoff
- Reactor ESD activation

**Required Operator Actions:**

- Immediately cut all heat input
- Prepare for emergency shutdown if temperature cannot be controlled
- Activate emergency response plan if containment is threatened
- Monitor for potential pressure relief
- Stop hydrogen injection immediately

**Prevention Measures:**

- Multiple temperature monitoring points
- Rate-of-change monitoring
- Product composition monitoring
- Automated emergency shutdown systems
- Conservative operating limits
- Regular testing of safety systems
- Operator training on runaway scenarios

# 7. Product Recovery Section Emergencies

## 7.1 Compressor Emergency

**Description:** Failure or significant malfunction of the reactor effluent compressor system, which is critical for product recovery.

**Potential Causes:**

- Mechanical failure (bearings, seals, impeller)
- Surge condition
- Lube oil system failure
- Motor/driver failure
- Excessive vibration
- Control system malfunction
- Fouling of compressor internals
- Suction or discharge valve issues

**Consequences:**

- Loss of compression capability
- Potential reactor section back-pressure
- Inability to process reactor effluent
- Required plant rate reduction or shutdown
- Damage to compressor components
- Loss of production
- Potential relief valve activation

**Detection Methods:**

- Surge indicators
- Vibration monitors
- Discharge pressure monitoring
- Performance curve deviations
- Lube oil parameters
- Motor current monitoring
- Temperature monitoring

- Seal system parameters

**Automatic Actions:**

- Anti-surge control system activation
- High vibration shutdown
- Low oil pressure shutdown
- High discharge temperature shutdown
- Load shedding during power fluctuations

**Required Operator Actions:**

1. For surge conditions:
- Verify anti-surge valve operation
- Adjust process conditions to move away from surge line
- Check for suction restrictions

2. For mechanical issues:
- Initiate startup of spare compressor (if available)
- Prepare for controlled plant rate reduction
- Monitor vibration and other mechanical parameters
- Initiate shutdown if damage is occurring

3. For all compressor issues:
- Evaluate impact on upstream reactor system
- Adjust reactor feed to match compression capability
- Prepare for flaring if necessary
- Coordinate with maintenance for response

**Prevention Measures:**

- Comprehensive compressor monitoring system
- Regular vibration analysis
- Lube oil analysis program
- Anti-surge control system

- Spare compressor or critical parts inventory
- Regular performance testing
- Fouling prevention program
- Operator training on compressor emergency procedures

## 7.2 Column Flooding

**Description:** Abnormal liquid accumulation in distillation columns (deethanizer or propylene/propane splitter) resulting in liquid entrainment, pressure drop increase, and separation efficiency loss.

**Potential Causes:**

- Excessive feed rate
- Low temperature in column
- Excessive reflux
- Reboiler failure
- Control valve malfunction
- Tray/packing damage
- Instrument failure
- Relief valve chattering
- Internal liquid distributor malfunction

**Consequences:**

- Severe separation efficiency loss
- Off-spec products
- High pressure drop across column
- Potential column internal damage
- Liquid carryover to overhead system
- Abnormal level control
- Potential relief valve activation

**Detection Methods:**

- Abnormal pressure drop across column
- Temperature profile disruptions
- Level control difficulties
- Flow ratio disturbances
- High reflux drum level
- Product quality deviations
- Unusual column differential pressures

**Automatic Actions:**

- Differential pressure monitoring
- Rate reduction systems
- High level alarms
- Automatic reflux adjustments

**Required Operator Actions:**

1. Reduce column load (feed rate)
2. Verify and adjust reflux ratio
3. Check reboiler operation
4. Ensure proper pressure control
5. Monitor temperature profiles
6. Adjust product withdrawals
7. If flooding persists:

- Further reduce rates
- Consider column depressurization
- Prepare for potential shutdown for inspection

**Prevention Measures:**

- Conservative operating limits
- Regular inspection of column internals
- Differential pressure monitoring

- Process control tuning
- Operating procedures for abnormal conditions
- Column load management procedures
- Regular testing of level instrumentation

## 7.3 Reboiler Failure

**Description:** Loss of heat input to column reboilers, compromising separation efficiency in the deethanizer or propylene/propane splitter.

**Potential Causes:**

- Steam supply failure
- Control valve malfunction
- Tube fouling or leakage
- Level control failure
- Steam trap issues
- Condensate system problems
- Instrument malfunction
- Mechanical damage

**Consequences:**

- Loss of separation capability
- Off-spec products
- Column temperature profile disruption
- Potential column flooding
- Production rate limitations
- Catalyst system impacts from recycle quality

**Detection Methods:**

- Steam flow reduction
- Reboiler outlet temperature drop
- Column temperature profile changes

- Abnormal level indications
- Bottom product quality changes
- Condensate system parameters

**Automatic Actions:**

- Low steam flow alarms
- Low temperature alarms
- Backup heating system activation (if available)
- Feed forward control adjustments

**Required Operator Actions:**

1. Verify steam supply system
2. Verify proper level in reboiler
3. Adjust column operation to compensate:

- Reduce feed rate
- Adjust reflux ratio
- Modify pressure control

4. If reboiler cannot be restored:

- Evaluate transition to alternate reboiler (if available)
- Prepare for rate reduction
- Consider hot vapor bypass if available
- Implement product blending strategies for off-spec material

**Prevention Measures:**

- Redundant steam supply
- Regular inspection of heat transfer surfaces
- Preventive maintenance on control valves
- Steam quality management
- Level control reliability improvement

## 7.4 Reflux System Failure

**Description:** Loss or significant reduction of column reflux flow, leading to compromise of separation efficiency in distillation columns.

**Potential Causes:**

- Reflux pump failure
- Condenser performance issues
- Control valve malfunction
- Loss of cooling medium
- Instrumentation failure
- Reflux drum level issues
- Power failure to pumps

**Consequences:**

- Separation efficiency loss
- Product purity reduction
- Column temperature profile disruption
- Potential damage to column internals
- Off-spec products
- Possible pressure excursions

**Detection Methods:**

- Low reflux flow alarms
- Temperature profile deviations
- Reflux drum level fluctuations
- Pump performance monitoring
- Condenser parameter monitoring
- Product purity analysis

**Automatic Actions:**

- Low flow alarms
- Automatic startup of spare pump

- Feed reduction on sustained low reflux
- Condenser controls adjustment

**Required Operator Actions:**

1. Verify reflux pump operation
2. Check condenser performance
3. Verify reflux drum level
4. For sustained reflux loss:
   - Reduce column feed rate proportionally
   - Adjust column pressure to compensate
   - Monitor product qualities
   - Prepare for potential off-spec products
5. If reflux cannot be restored:
   - Consider column shutdown
   - Implement product quarantine procedures
   - Prepare for restart planning

**Prevention Measures:**

- Redundant reflux pumps
- Regular condenser performance monitoring
- Cooling water reliability improvements
- Level control system maintenance
- Control valve maintenance program
- Operator training on reflux management
- Automation of feed-to-reflux ratio control

## 7.5 Product Quality Excursion

**Description:** Production of off-specification propylene product that does not meet purity or contaminant specifications.

**Potential Causes:**

- Column operating parameter deviations
- Feed composition changes
- Equipment malfunction
- Control system issues
- Analytical instrument failure
- Contamination from utility systems
- Improper operating procedures

**Consequences:**

- Off-spec product requiring downgrade or reprocessing
- Potential contamination of product storage
- Production rate limitations
- Economic impact
- Customer quality complaints
- Potential downstream process impacts

**Detection Methods:**

- Online analyzers
- Laboratory sample analysis
- Column operating parameter monitoring
- Product physical properties (density, vapor pressure)
- Abnormal temperature profiles
- Unexpected pressure or flow relationships

**Automatic Actions:**

- Product quality alarms
- Feed forward control adjustments

**Required Operator Actions:**

1. Verify analyzer accuracy with lab samples
2. Check column operating parameters

3. Verify feed composition
4. Implement quality recovery procedures:

- Adjust reflux ratio
- Modify column pressure
- Adjust heat input
- Change product withdrawal rates

5. If quality cannot be quickly restored:

- Divert product to off-spec storage
- Implement blending strategies if applicable
- Consider rate reduction
- Evaluate reprocessing options

**Prevention Measures:**

- Regular analyzer calibration
- Feed quality monitoring program
- Robust control system design
- Operator training on quality management
- Quality excursion response procedures
- Product quarantine capabilities
- Feedback control from analyzers to process

# 8. Utilities Failure Scenarios

## 8.1 Cooling Water System Failure

**Description:** Loss or significant reduction of cooling water supply, affecting multiple process units including compressor intercoolers, condensers, and other heat exchangers.

**Potential Causes:**

- Cooling tower fan failure
- Circulation pump failure

- Distribution system leak
- Fouling of heat exchangers
- Instrumentation failure
- Power loss to cooling system
- Environmental factors (high ambient temperature, storm damage)
- Water quality issues

**Consequences:**

- Reduced cooling capacity
- High temperature in cooled equipment
- Compressor trip potential
- Reduced condensing in overhead systems
- Potential pressure excursions
- Production rate limitations
- Multiple unit impacts

**Detection Methods:**

- Flow indicators on cooling water headers
- Temperature indicators on return water
- Pressure indicators on supply system
- Individual cooler temperature monitoring
- Cooling tower parameter monitoring
- Pump performance indicators

**Automatic Actions:**

- Low flow alarms
- High temperature alarms
- Backup pump startup
- Critical equipment protection systems
- Load shedding for partial failures

**Required Operator Actions:**

1. Identify the specific failure mode
2. Start backup systems if available
3. Prioritize cooling to critical equipment
4. Reduce heat load by process adjustments:

- Reduce reaction rates
- Decrease compression ratios
- Adjust column pressures

5. Monitor temperatures of critical equipment
6. If cooling cannot be restored:

- Implement controlled rate reduction
- Prepare for equipment shutdown sequence

**Prevention Measures:**

- Redundant cooling water pumps
- Multiple cooling tower cells
- Regular maintenance of cooling systems
- Water treatment program
- Fouling monitoring
- Winterization where applicable
- Regular testing of backup systems

## 8.2 Steam System Failure

**Description:** Loss or significant reduction of steam supply affecting heating systems, reboilers, steam tracing, and steam-driven equipment.

**Potential Causes:**

- Boiler failure
- Steam header leak
- Control system malfunction

- Feedwater issues
- Fuel supply interruption
- Safety system activation
- Contamination of steam system
- Condensate return problems

**Consequences:**

- Loss of heating capability
- Reboiler performance reduction
- Column temperature profile disruptions
- Separation efficiency losses
- Potential freezing in cold weather
- Steam-driven equipment failure
- Multiple unit impacts

**Detection Methods:**

- Steam header pressure monitoring
- Flow measurements
- Steam quality monitoring
- Condensate return parameters
- Boiler performance indicators
- Temperature indicators on steam-heated equipment

**Automatic Actions:**

- Low pressure alarms
- Automatic pressure reducing station adjustments
- Priority-based load shedding
- Condensate system protection

**Required Operator Actions:**

1. Identify the specific failure mode

2. Prioritize steam to critical services
3. Reduce steam consumption where possible
4. Monitor temperatures of critical equipment
5. For specific systems:

- Adjust column operations for reduced reboiler duty
- Implement alternative heating methods where available
- Protect equipment from potential freezing

6. If steam cannot be restored:

- Implement controlled rate reduction
- Prepare for equipment shutdown sequence
- Activate alternative heating systems where available

**Prevention Measures:**

- Multiple steam generation sources
- Boiler maintenance program
- Steam trap maintenance program
- Condensate quality monitoring
- Fuel supply backup systems
- Winterization protocols

## 8.3 Electrical Power Failure

**Description:** Complete loss (blackout) or partial loss (brownout) of electrical power supply affecting multiple plant systems.

**Potential Causes:**

- Utility grid failure
- Internal electrical distribution failure
- Transformer failure
- Switchgear issues
- Lightning or storm damage

- Generator failure
- Short circuit or ground fault
- Load imbalance or overload

**Consequences:**

- Loss of electrically-driven equipment
- Control system disruption
- Instrumentation failure
- Lighting and communication issues
- Safety system impacts
- Potential emergency shutdown activation
- Cooling and HVAC system failures

**Detection Methods:**

- Power monitoring systems
- Voltage and frequency monitoring
- UPS status indicators
- Generator status indicators
- Equipment startup failure
- Multiple simultaneous equipment trips

**Automatic Actions:**

- Emergency generator startup
- UPS activation
- Automatic load shedding
- Emergency lighting activation
- Fail-safe positioning of critical valves
- Emergency shutdown system activation

**Required Operator Actions:**

1. For complete power loss:

- Verify emergency power system operation
- Ensure critical equipment protection
- Implement emergency shutdown procedures
- Monitor for hazardous conditions
- Prepare for controlled restart when power is restored

2. For partial power loss:

- Identify affected systems
- Reduce process rates to match available power
- Prioritize power to critical systems
- Monitor for process upsets
- Prepare for potential escalation to complete shutdown

3. Upon power restoration:

- Implement systematic restart procedures
- Verify system integrity before resuming operation
- Coordinate startup sequence to prevent overloading

**Prevention Measures:**

- Multiple power feeds from utility
- Emergency generators for critical systems
- Uninterruptible power supplies for control systems
- Regular testing of backup power systems
- Load shedding procedures
- Electrical distribution maintenance program
- Surge protection systems
- Lightning protection systems

## 8.4 Instrument Air Failure

**Description:** Loss or significant reduction of instrument air supply affecting pneumatic control valves, instruments, and pneumatic operators throughout the plant.

**Potential Causes:**

- Air compressor failure
- Air dryer failure
- Distribution system leak
- Filter plugging
- Excessive demand
- Contamination of system
- Control system malfunction
- Power loss to compressors

**Consequences:**

- Control valve failure (typically to fail position)
- Loss of pneumatic instrument function
- Pneumatic actuator failure
- Multiple control loop disruptions
- Cascading process upsets
- Potential emergency shutdown activation

**Detection Methods:**

- Air header pressure monitoring
- Compressor performance indicators
- Dewpoint monitoring
- Air quality monitoring
- Multiple instrument failures
- Control valve position discrepancies

**Automatic Actions:**

- Low pressure alarms
- Backup compressor startup
- Fail-safe positioning of critical valves

**Required Operator Actions:**

1. Identify the specific failure mode
2. Start backup compressors if available
3. Check for and isolate major leaks
4. Prioritize air to critical services
5. Monitor positions of critical valves
6. For significant air loss:

- Implement manual operation of critical valves where possible
- Prepare for controlled shutdown if control cannot be maintained
- Switch to nitrogen backup where available
- Monitor for hazardous conditions resulting from valve failures

**Prevention Measures:**

- Multiple air compressors
- Air receiver capacity for buffer
- Regular leak detection and repair
- Backup nitrogen supply for critical services
- Regular air quality testing
- Preventive maintenance on air system components
- Fail-safe design of critical valves
- Alternative control mechanisms for critical systems

## 8.5 Nitrogen System Failure

**Description:** Loss or significant reduction of nitrogen supply used for purging, blanketing, and as backup for instrument air in critical services.

**Potential Causes:**

- Nitrogen generation system failure
- Storage depletion
- Distribution system leak

- Supply interruption (for delivered nitrogen)
- Excessive demand
- Control system malfunction
- Contamination of system

**Consequences:**

- Loss of purge capability
- Reduced blanketing of vessels and tanks
- Compromised catalyst protection
- Potential air ingress into process
- Loss of backup for instrument air
- Impact on catalyst transfer operations

**Detection Methods:**

- Nitrogen header pressure monitoring
- Flow measurements
- Oxygen content monitoring
- Storage level indicators
- Generator performance parameters
- Pressure drop in distribution system

**Automatic Actions:**

- Low pressure alarms
- Backup supply activation
- Priority-based distribution

**Required Operator Actions:**

1. Identify the specific failure mode
2. Activate backup nitrogen sources if available
3. Prioritize nitrogen to critical services:

- Catalyst systems

- Flammable material storage
- Safety purge systems

4. Reduce consumption where possible
5. Monitor for potential air ingress
6. For significant nitrogen loss:

- Implement alternative purge methods where feasible
- Consider controlled equipment shutdown for affected systems
- Monitor for development of hazardous conditions

**Prevention Measures:**

- Multiple nitrogen sources
- Adequate storage capacity
- Regular system integrity checks
- Backup supply arrangements
- Consumption monitoring
- Critical service identification and prioritization

# 9. Environmental Release Scenarios

## 9.1 Flammable Gas Release

**Description:** Unplanned release of flammable gases (propane, propylene, hydrogen) to the atmosphere creating potential fire and explosion hazards.

**Potential Causes:**

- Equipment leak (flanges, valves, seals)
- Pipeline breach
- Relief valve activation
- Process vessel overpressure
- Loading/unloading operations
- Drain or sample point misoperation

- Maintenance activity gone wrong
- Catastrophic equipment failure

**Consequences:**

- Fire or explosion potential
- Personnel safety hazard with possibility of fatality
- Equipment damage potential
- Community impact potential
- Environmental impact
- Regulatory reporting requirements
- Potential emergency shutdown
- Production loss

**Detection Methods:**

- Fixed gas detection systems
- Portable gas detection
- Visual observation (cloud, frost formation)
- ~~Deleted~~
- Pressure loss in systems
- Unexpected material balance discrepancies
- Noise from release
- Odor detection (for odorized streams)

**Automatic Actions:**

- Gas detection alarms
- Automatic isolation of affected areas
- Deluge system activation (if fire detected) and other automatic system such as gaseous system
- Emergency shutdown activation
- Ventilation system response and air extraction (if required)

- Emergency notification systems such as horn & beacon

**Required Operator Actions:**

1. Confirm release location and magnitude
2. Activate emergency response plan
3. Evacuate non-essential personnel from affected area
4. If safe to do so:
   - Isolate source of release
   - Shut down affected equipment
   - Depressurize to flare if possible
5. Activate water sprays for fire detection if available
6. Eliminate ignition sources
7. Monitor gas concentrations in surrounding areas refer to HSE plan ERP
8. Notify appropriate internal and external entities refer to HSE plan ERP
9. Implement community protection measures if needed refer to HSE plan ERP

**Prevention Measures:**

- Leak detection and repair program
- Regular equipment inspection
- Preventive maintenance
- Relief system design and maintenance
- Operating procedures for hazardous operations such as permit to work or PSSR
- Training on emergency response
- Process hazard analysis
- Safety instrumented systems
- Fire proofing

## 9.2 Liquid Hydrocarbon Release

**Description:** Unplanned release of liquid hydrocarbons (propane, propylene, other process liquids) creating potential fire, explosion, and environmental hazards.

**Potential Causes:**

- Equipment leak (flanges, pumps, heat exchangers)
- Pipeline breach
- Tank overflow
- Drain valve misoperation
- Loading/unloading operations
- Level control failure
- Maintenance activity gone wrong
- Catastrophic equipment failure

**Consequences:**

- Fire or explosion potential (after vaporization)
- Personnel safety hazard
- Soil and water contamination
- Slip hazards on surfaces
- Regulatory reporting requirements
- Production loss
- Community and environmental impact
- Potential emergency shutdown

**Detection Methods:**

- Visual observation
- Liquid level discrepancies
- Infrared cameras
- Pressure loss in systems
- Unexpected material balance discrepancies
- Liquid detection systems
- Sump level alarms
- Odor detection

**Automatic Actions:**

- Liquid detection alarms
- Level alarm activations
- Sump pump activation
- Emergency shutdown activation
- Emergency notification systems

**Required Operator Actions:**

1. Confirm release location and magnitude
2. Activate emergency response plan
3. Evacuate non-essential personnel from affected area
4. If safe to do so:
   - Isolate source of release
   - Shut down affected equipment
   - Contain the spill using available means
5. Eliminate ignition sources
6. For refrigerated liquid releases:
   - Be aware of cold temperature hazards
   - Use appropriate PPE for response
   - Monitor for vapor cloud formation
7. Implement cleanup procedures
8. Notify appropriate internal and external entities
9. Document release for reporting purposes

**Prevention Measures:**

- Secondary containment systems
- Level monitoring and control systems
- Regular equipment inspection
- Preventive maintenance

- Operating procedures for hazardous operations
- Spill response training
- Material balance monitoring
- Loading/unloading procedures

## 9.3 Acid/Caustic Release

**Description:** Unplanned release of acids, caustics, or other corrosive materials used in the PDH plant for cleaning, regeneration, or water treatment.

**Potential Causes:**

- Container failure
- Pipeline breach
- Transfer operation errors
- Incompatible material mixing
- Overfilling of storage
- Drain valve misoperation
- Maintenance activity gone wrong
- Dosing system malfunction

**Consequences:**

- Personnel chemical exposure hazard
- Equipment corrosion damage
- Soil and water contamination
- Reaction with other materials
- Regulatory reporting requirements
- Neutralization requirements
- Waste disposal issues

**Detection Methods:**

- Visual observation
- pH monitoring

- Chemical detection systems
- Unexpected material consumption
- Storage level discrepancies
- Dosing system alarms
- Corrosion in affected areas
- Odor detection

**Automatic Actions:**

- PH alarms
- Automatic isolation of dosing systems
- Ventilation system activation
- Emergency shower/eyewash alarms

**Required Operator Actions:**

1. Confirm release location and nature of material
2. Activate emergency response plan
3. Evacuate non-essential personnel from affected area
4. Ensure appropriate PPE for responders
5. If safe to do so:

- Isolate source of release
- Contain the spill using appropriate methods
- Prevent incompatible material contact

6. For personnel exposure:

- Utilize emergency shower/eyewash
- Seek medical attention immediately

7. Implement neutralization procedures appropriate for the material
8. Notify appropriate internal and external entities
9. Document release for reporting purposes

**Prevention Measures:**

- Secondary containment for storage
- Compatibility analysis for materials
- Appropriate material selection for equipment
- Chemical handling training
- Clear labeling of all chemicals
- Appropriate transfer procedures
- pH monitoring systems
- Dosing system design and maintenance

## 9.4 Release to Flare System

**Description:** Significant or prolonged release of process materials to the flare system due to process upsets, equipment failure, or emergency depressuring.

**Potential Causes:**

- Process upset requiring pressure relief
- Emergency depressuring of equipment
- Relief valve activation
- Blowdown system activation
- Control valve failure
- Level control failure
- Power failure
- Cooling system failure

**Consequences:**

- Visible and audible flaring
- Air emissions and potential permit exceedances
- Community concern and complaints
- Heat radiation in flare area
- Potential smoking flare (incomplete combustion)
- Regulatory reporting requirements

- Production loss
- Potential emergency shutdown

**Detection Methods:**

- Flare header pressure monitoring
- Flow monitoring to flare
- Visual observation of flare
- Relief valve position indicators
- Process parameter excursions
- Multiple relief events
- Noise from relief valves/flare

**Automatic Actions:**

- High flare header pressure alarms
- Automatic load reduction systems
- Flare gas recovery system bypassing
- Flare ignition verification
- Steam injection for smoke suppression

**Required Operator Actions:**

1. Identify source of release to flare
2. Take appropriate actions to stabilize process:

- Reduce feed rates
- Adjust operating parameters
- Isolate non-essential equipment

3. Monitor flare system capacity and backpressure
4. Ensure flare is operating properly:

- Proper ignition
- Adequate steam for smoke suppression

5. Prepare documentation for environmental reporting

6. For extended flaring:

- Notify appropriate authorities
- Implement community notification if required
- Consider plant rate reduction to minimize flaring

**Prevention Measures:**

- Process control improvements
- Relief scenario analysis and mitigation
- Flare gas recovery systems
- Preventive maintenance of relief devices
- Operating procedures for upset conditions
- Training on flare minimization
- Relief valve testing program
- Process hazard analysis

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## 11.Safety Relief Scenarios

### 11.1 Process Vessel Relief

**Description:** Activation of pressure relief devices on process vessels to prevent overpressure and potential vessel failure.

**Potential Causes:**

- Blocked outlet while heat input continues
- External fire exposure
- Thermal expansion of trapped liquid
- Chemical reaction runaway
- Loss of cooling
- Control valve failure

- Inadvertent valve closure
- Reflux failure in distillation
- Power failure affecting control systems

**Relief Pathways:**

- Pressure Safety Valves (PSVs) to closed relief header
- Relief header to flare system
- ~~Deleted~~
- ~~Deleted~~

**Relief Sizing Basis:**

- Blocked outlet: Based on maximum inlet flow
- Fire# Description of Process Emergency Conditions for Process Units
- Relief Sizing Basis: **
- Blocked outlet: Based on maximum inlet flow
- Fire case: Based on API 521 heat input calculations
- Thermal expansion: Based on solar radiation or ambient heat gain
- Control valve failure: Based on full open flow capacity
- Reaction case: Based on maximum reaction rate

**Detection Methods:**

- Relief valve position indicators (if installed)
- Upstream pressure increasing to relief pressure
- Acoustic monitors on relief lines
- Flow indication in relief system
- Visual or audible indication of relief
- Temperature changes in relief lines
- Flare activity corresponding to relief

**Automatic Actions:**

- High pressure alarms prior to relief

- Automated depressuring systems (for fire cases)
- Relief system containment verification

**Required Operator Actions:**

1. Identify the relieving vessel and cause
2. Take actions to reduce pressure if safe:
   - Reduce heat input
   - Open blocked flow paths
   - Increase cooling
   - Divert feeds
3. Verify relief valve reseating after pressure reduction
4. Monitor vessel condition during and after relief
5. Assess downstream relief system impacts
6. Document the relief event for investigation
7. Prepare for potential regulatory reporting

**Prevention Measures:**

- High pressure alarms and automated responses
- Regular inspection and testing of relief devices
- Process hazard analysis for relief scenarios
- Administrative controls for high-risk operations
- Preventive maintenance of control valves
- Operating procedures for pressure management
- Training on overpressure scenarios
- Regular relief system capacity verification

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~~**11.3 Deleted**~~

## 11.4 Flare System Overload

**Description:** Excessive flow to the flare system exceeding its design capacity, potentially causing unsafe operation, smoking, flame instability, or radiation hazards.

**Potential Causes:**

- Multiple relief events occurring simultaneously
- Emergency depressuring of large equipment
- Major process upset affecting multiple units
- Improper unit startup or shutdown procedures
- Power failure affecting multiple systems
- Cooling water failure affecting multiple condensers
- Instrument air failure affecting multiple control valves
- Control system failure

**Consequences:**

- Excessive flare header backpressure
- Relief valve chattering
- Incomplete combustion (smoking flare)
- Increased radiation hazard zones
- Potential flame instability or extinguishment
- Noise complaints
- Air emission exceedances
- Regulatory reporting requirements

**Detection Methods:**

- Flare header pressure monitoring
- ~~Deleted~~
- Visual observation of flare quality
- ~~Deleted~~
- ~~Deleted~~

- Multiple relief valve activations
- Vibration in flare headers

**Automatic Actions:**

- High flare header pressure alarms
- ~~Deleted~~
- Flare ignition verification
- ~~Deleted~~
- ~~Deleted~~

**Required Operator Actions:**

1. Identify sources contributing to flare load
2. Take actions to reduce flare system loading:
   - Stop non-critical depressuring activities
   - Stabilize upset process units
   - Reduce plant rates where possible
   - Restore utility systems if applicable
3. Monitor flare header pressure continuously
4. Ensure proper flare combustion (steam/air assist)
5. Establish appropriate flare radiation exclusion zones
6. Notify appropriate authorities for significant flaring
7. Document flaring event for investigation and reporting

**Prevention Measures:**

- Adequate flare system design with margin
- Flare load management procedures
- Staged depressuring systems
- Relief scenario analysis and mitigation
- ~~Deleted~~
- Preventive maintenance on relief devices

- Training on flare system limitations
- Flare system hydraulic analysis

# 12.Startup And Shutdown Risks

## 12.1 Plant Startup Hazards

**Description:** Unique hazards and elevated risks associated with the startup of process units after construction, maintenance, or emergency shutdown.

**Critical Startup Phases:**

- Initial pressurization
- Introduction of hydrocarbons
- Catalyst reduction/activation
- Establishing recycle flows
- Transition to reaction temperatures
- Product specification achievement
- Integration of units

**Potential Hazards:**

- Leaks from improperly assembled equipment
- Air/hydrocarbon explosive mixtures
- Unstable control during transition states
- Exothermic reactions during catalyst activation
- Thermal stresses during heating
- Liquid hammer in steam systems
- Improper equipment lineup
- Rapid pressure or temperature changes
- Reactive chemical mixing
- Control system configuration errors

**Detection Methods:**

- Systematic leak testing
- Oxygen analysis before hydrocarbon introduction
- Careful process parameter monitoring
- Visual inspection during critical phases
- Vibration monitoring during transitions
- Gas detection during pressurization
- Material balance verification

**Required Operator Actions:**

1. Follow detailed startup procedures precisely
2. Complete and verify all pre-startup safety checks
3. Establish proper communications between field and control room
4. Monitor critical parameters at increased frequency
5. Proceed at conservative rates through transition phases
6. Verify each critical step before proceeding
7. Maintain log of all startup activities
8. Be prepared to halt startup if abnormal conditions develop
9. Monitor utilities and support systems continuously
10. Verify all safety systems are active before introducing hazardous materials

**Risk Mitigation Measures:**

- Detailed, step-by-step startup procedures
- Pre-startup safety review (PSSR)
- Enhanced staffing during startup
- Management presence and oversight
- Optimization of daylight operations for critical steps
- Equipment walkdowns before energizing
- Testing of critical alarms and interlocks
- Establishment of clear hold points and approvals

- Conservation rate progression through critical phases
- Contingency plans for common startup issues

## 12.2 Planned Shutdown Hazards

**Description:** Specific hazards associated with the planned shutdown of process units for maintenance, catalyst change, or other scheduled activities.

**Critical Shutdown Phases:**

- Production rate reduction
- Feed cutoff
- Equipment depressuring
- Cooling to ambient temperature
- Isolation and blinding
- Nitrogen purging
- Catalyst handling
- Equipment opening

**Potential Hazards:**

- Transient conditions during rate changes
- Liquid hammer during depressuring
- Formation of vacuum during cooling
- Pyrophoric material ignition (iron sulfides)
- Trapped pressure release
- Residual hydrocarbon exposure
- Hydrogen embrittlement release
- Cross-contamination during blinding
- Confined space entry hazards
- Catalyst handling hazards (dust, toxicity)

**Detection Methods:**

- Process parameter monitoring

- Vessel pressure monitoring during cooling
- ~~Deleted~~
- ~~Deleted~~
- ~~Deleted~~
- Catalyst properties verification
- Isolation verification checks

**Required Operator Actions:**

1. Follow detailed shutdown procedures precisely
2. Monitor cooling rates to prevent thermal stress
3. Verify complete depressuring before equipment opening
4. Ensure proper isolation and blinding
5. Verify adequate purging and gas testing
6. Handle catalyst according to safety procedures
7. Implement confined space entry protocols
8. Maintain management of change for procedure deviations
9. Document all shutdown activities
10. Implement proper handover to maintenance

**Risk Mitigation Measures:**

- Detailed, step-by-step shutdown procedures
- Pre-shutdown safety review
- Enhanced staffing during critical phases
- Shutdown planning and scheduling
- Equipment-specific isolation procedures
- Verification of isolation by multiple methods
- Proper catalyst handling protocols
- Coordination with maintenance activities
- Clear specification of equipment condition requirements

- Contingency plans for common shutdown issues

## 12.3 Catalyst Handling Hazards

**Description:** Specific hazards associated with the handling, loading, unloading, and regeneration of the platinum-based catalyst used in the PDH process.

**Critical Catalyst Activities:**

- Fresh catalyst loading
- Spent catalyst unloading
- Catalyst transfer during operation
- Ex-situ regeneration
- Catalyst screening
- Dust management
- Disposal of spent catalyst

**Potential Hazards:**

- Pyrophoricity of reduced catalyst
- Platinum compounds toxicity
- Dust explosion potential
- Confined space hazards during loading/unloading
- Personnel exposure to catalyst materials
- Catalyst fines in the environment
- Fire during handling of incompletely passivated catalyst
- Chemical exposure during regeneration

**Detection Methods:**

- Temperature monitoring during handling
- Oxygen monitoring in confined spaces
- Dust monitoring in work areas
- Visual inspection of catalyst condition
- Personal exposure monitoring

- Gas testing before vessel entry
- Catalyst activity testing

**Required Operator Actions:**

1. Follow detailed catalyst handling procedures
2. Use appropriate personal protective equipment
3. Ensure proper catalyst passivation before handling
4. Monitor for signs of catalyst heating or smoking
5. Control air exposure for pyrophoric materials
6. Implement dust control measures
7. Verify proper isolation before opening catalyst systems
8. Implement confined space protocols for vessel entry
9. Handle catalyst according to material safety data sheet
10. Document all catalyst handling activities

**Risk Mitigation Measures:**

- Detailed catalyst handling procedures
- Specialized contractor support where needed
- Specific training on catalyst hazards
- Appropriate handling equipment
- Nitrogen purging and blanketing
- Controlled oxidation/passivation protocols
- Proper catalyst packaging and storage
- Dust control and ventilation systems
- Emergency response preparations
- Catalyst manufacturer technical support

# 13.Post-Emergency Recovery

## 13.1 Post-Emergency Assessment

**Description:** Systematic evaluation of plant condition after an emergency to determine the extent of damage, required repairs, and safety of restart operations.

**Assessment Areas:**

- Equipment mechanical integrity
- Control system functionality
- Safety system status
- Environmental impacts
- Personnel impacts
- Utility system condition
- Catalyst condition
- Product quality impacts
- Regulatory compliance status

**Assessment Methods:**

- Visual inspection of affected areas
- Non-destructive testing of critical equipment
- Control system diagnostics
- Safety system function testing
- Environmental sampling
- Documentation review
- Incident investigation findings
- Root cause analysis

**Required Actions:**

1. Establish assessment team with appropriate expertise
2. Develop systematic assessment plan
3. Prioritize critical safety systems for evaluation
4. Document all findings thoroughly
5. Identify repair and restoration requirements

6. Determine testing needs before restart
7. Evaluate catalyst condition and performance impact
8. Assess environmental remediation requirements
9. Identify regulatory notification requirements
10. Develop comprehensive recovery plan

**Documentation Requirements:**

- Comprehensive damage assessment report
- Photographic documentation
- Testing and inspection records
- Repair recommendations
- Safety system verification
- Environmental impact assessment
- Root cause investigation findings
- Regulatory compliance status
- Restart requirements and limitations

## 13.2 Equipment Restart Requirements

**Description:** Specific requirements that must be met before restarting equipment or process units after an emergency shutdown.

**Restart Prerequisites:**

- Mechanical integrity verification
- Safety system functionality
- Control system validation
- Utility system availability
- Material availability (feed, catalysts, chemicals)
- Personnel readiness
- Regulatory compliance
- Management approval

- Emergency system readiness
- Communication plan

**Testing Requirements:**

- Pressure testing of affected systems
- Control loop verification
- Interlock and trip testing
- Relief system verification
- Rotating equipment mechanical checks
- Instrumentation calibration verification
- Leak testing
- Electrical system checks

**Required Actions:**

- Develop detailed restart procedure specific to the emergency
- Conduct pre-startup safety review
- Verify completion of all required repairs
- Test all affected safety systems
- Calibrate critical instrumentation
- Verify proper valve lineup
- Establish appropriate staffing for restart
- Review emergency response readiness
- Obtain appropriate management approvals
- Document all restart activities

**Risk Mitigation Measures:**

- Conservative approach to restart activities
- Enhanced monitoring during initial restart
- Staged restart of integrated systems
- Clear abort criteria for restart activities

- Contingency plans for restart issues
- Technical support presence during critical phases
- Management oversight during restart
- Regular status updates and reviews

## 13.3 Incident Investigation

**Description:** Formal process to determine the causes of an emergency event, identify contributing factors, and develop preventive actions.

**Investigation Scope:**

- Direct causes of the incident
- Contributing factors
- Root causes
- Management system deficiencies
- Human factors
- Equipment factors
- Procedural factors
- External factors
- Emergency response effectiveness

**Investigation Methods:**

- Timeline development
- Witness interviews
- Physical evidence examination
- Document review
- Process data analysis
- Failure analysis
- Root cause analysis techniques
- Human factors analysis
- Comparative analysis with similar events

**Required Actions:**

1. Form investigation team with appropriate expertise
2. Preserve incident scene and evidence
3. Gather process data and records
4. Conduct witness interviews
5. Analyze physical evidence
6. Develop incident timeline
7. Identify causal factors
8. Conduct root cause analysis
9. Develop recommendations
10. Document findings and conclusions

**Documentation Requirements:**

- Formal investigation report
- Evidence documentation
- Analysis methodology
- Factual findings
- Root cause determination
- Recommendations for prevention
- Action item assignments
- Timeline for implementation
- Verification requirements
- Communication plan

## 13.4 Regulatory Reporting

**Description:** Requirements for reporting emergency events to regulatory agencies in accordance with applicable regulations.

**Reportable Events:**

- Releases exceeding reportable quantities

- Injuries or fatalities
- Community impact events
- Fires and explosions
- Environmental impact incidents
- Process safety management incidents
- Permit exceedances
- Equipment failures affecting safety systems

**Reporting Timeframes:**

- Immediate notification (typically 15 minutes - 1 hour)
- 24-hour follow-up reports
- 7-day written reports
- 30-day detailed reports
- Annual summary reports

**Required Actions:**

1. Determine reporting requirements based on event classification
2. Gather essential information for initial reports
3. Make initial notifications within required timeframes
4. Document all communications with agencies
5. Prepare follow-up reports with additional information
6. Conduct any required agency meetings or briefings
7. Provide investigation findings as required
8. Track compliance with regulatory requirements
9. Retain all reporting documentation

**Documentation Requirements:**

- Initial notification records
- Written follow-up reports
- Investigation findings for agencies

- Corrective action plans
- Environmental sampling results
- Medical surveillance results
- Correspondence with regulatory agencies
- Meeting minutes from agency interactions

## 14. References


1. UOP Oleflex™ PDH Technology Documentation
2. API RP 521: Pressure-relieving and Depressuring Systems
3. API RP 750: Management of Process Hazards
4. CCPS Guidelines for Safe Process Operations and Maintenance
5. NFPA 30: Flammable and Combustible Liquids Code
6. OSHA 29 CFR 1910.119: Process Safety Management of Highly Hazardous Chemicals
7. EPA 40 CFR Part 68: Risk Management Program
8. Plant-specific Process Hazard Analysis (PHA) Documentation
9. Plant Emergency Response Plan
10. Plant Standard Operating Procedures
11. Plant Process Safety Information
12. Plant-specific Relief System Design Basis
13. Catalyst Manufacturer Safety Information