Process Plant Design

Interlocks

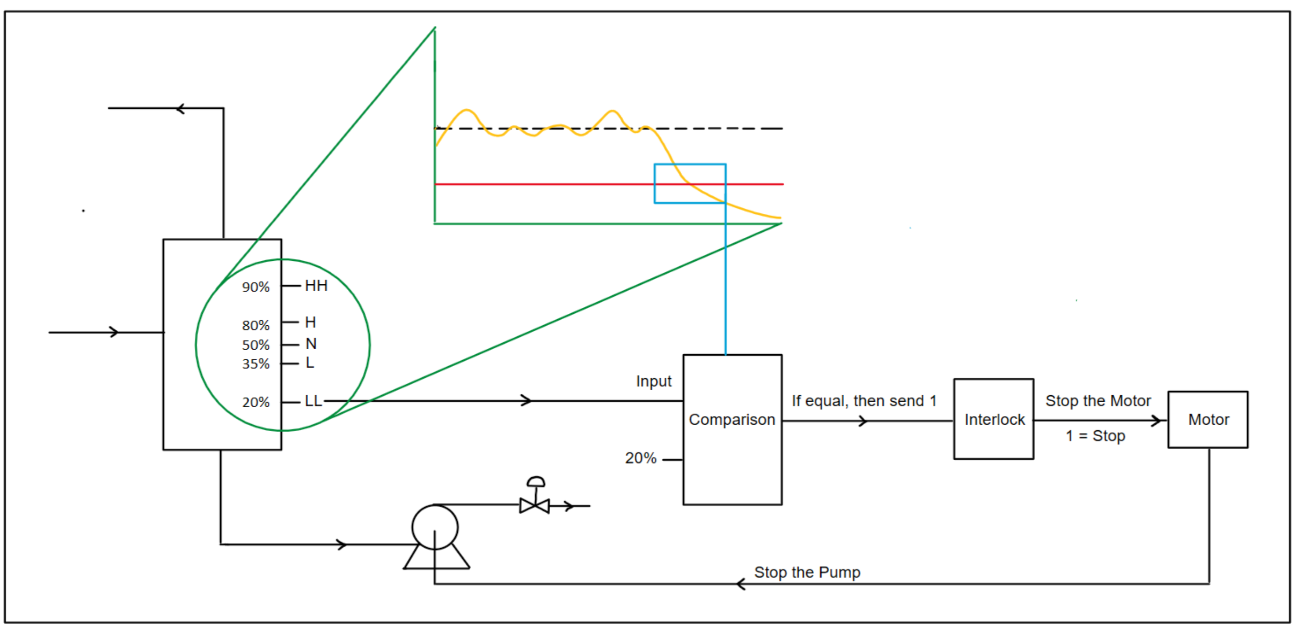
Simple interlock definition:

Interlocks are added to plant design and as a result are shown on P&IDs to maintain safety and prevent damage.

To better understand let's have a look at the following practical example from our last projects.

The mixture enters the separator, and by means of separator, the process water is separated and then pumped to another unit. As usual, there is a LV which controls level of the separator. The control room operator during start-up, before putting the control valve in auto mode, was adjusting the control valve manually. Instead of opening the valve by 9%, gives the value of 90%. Now a great portion of process water in a moment passes through the control valve and the level decreases suddenly. Look at the picture! The level reaches zero percent and it damages the pump due to no flow.

We can't prevent human error but we can prevent damage to the pump. But how? Interlock. Imagine the level below 20% is dangerous for the pump. How about this idea. We put a comparison block in monitoring system [DCS/FCS] and continuously receives the actual level and compares it with 20%. It functions in a way that the moment the actual level equals 20%, it sends the signal of 1 in a binary system to the interlock block. The interlock block sends 1 to the motor and since in motor terminology 1 means Stop, then the motor stops. Since the motor is the driver of the pump, the pump also stops working. Perfect idea! Right!



Now let's discuss it in a more professional manner the way it deserves!

A number of instruments in the plant are equipped with passive alarms to warn the operators in the control room against deviating operating conditions, which may lead to dangerous situations or which may cause damage to the equipment or the catalysts.

Critical parameters such as essential flows, pressures and temperatures are provided with active alarms connected to the safety interlock trip system. Some of the above passive alarms are acting as pre-alarms for the active alarms.
These active alarms will initiate automatic safety actions to safely shut down certain process sections in order to protect the personnel and the equipment of the plant against hazards.
When a trip group has been activated, operators must act to maintain safe operating conditions in the plant.

Furthermore, there are a number of interlock systems, which activate a shut-down of pumps, start-up equipment and other equipment if process parameters deviate too much.

Due to a considerable higher cost of IS than DCS hardware, consideration has been given to define which actions (groups) are to be performed in the IS system and which actions are to be performed in the DCS. Action performed in the IS are called IS-group (Interlock Safety) and actions performed in the DCS are called I-group (Interlock). In order to establish guidelines for the distinction of those actions, the following rules are applied:

Trips in IS groups are generally based on 2-out-of-3 voting.

IS-groups must protect:
- personnel against safety hazards
- critical plant equipment
- unit trips which will result in a significant production loss when initiated

I-groups must protect:
- auto start and stop of motors
- avoidance of PSV relief
- switching of operating mode

Example 1: For the above example, develop Interlock Diagram and the “Process Emergency Description”.

Let’s start with Process Emergency Description and then develop Interlock Diagram based on it.

We professionals develop Process Emergency Descriptions like below:

IS-X: Name of the Interlock

The causes for the trip are:
- First cause
- Second cause
- The remaining causes

The following actions are carried out automatically:

- First action which leads to a safe position or help revert to normalcy

- Second action which leads to a safe position or help revert to normalcy

That's it. As simple as this!

Let's apply the above rule for the example.

IS-33: Trip of the separator

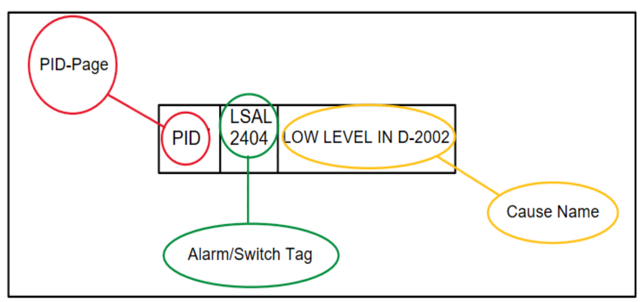
The causes for the trip are:
- Manual panel trip [push button]-We always have it.
- Low level in the separator, D-2002, LSAL-2404

The following actions are carried out automatically:
- Stop the pump P 2001 A, stop MP-2001A
- Stop the pump P 2001 B, stop MP-2001B
- Close LV-2403

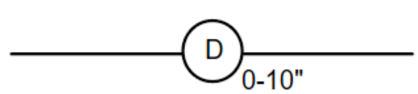
Now it is time to develop the Interlock Diagram.

To draw the interlock, we need to show the followings:

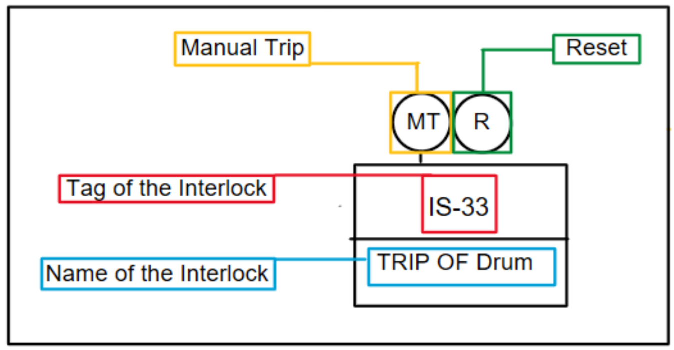
1.Cause — P&ID Page
— Alarm/Switch Tag
— Cause Name



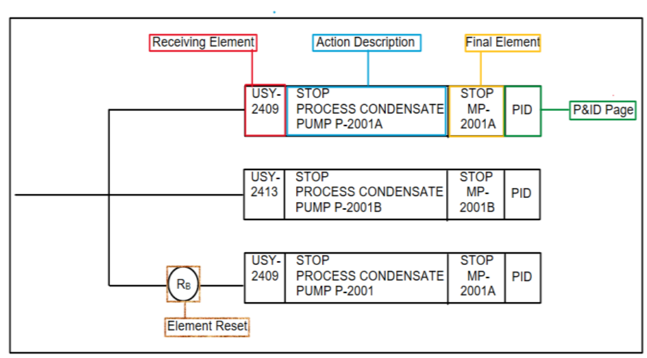
2.Delays — Sometimes the output of transmitter is Spurious [can't be trusted] and in a second it self-adjusts. So, in order to avoid that trip which is unnecessary, we introduce delay time.



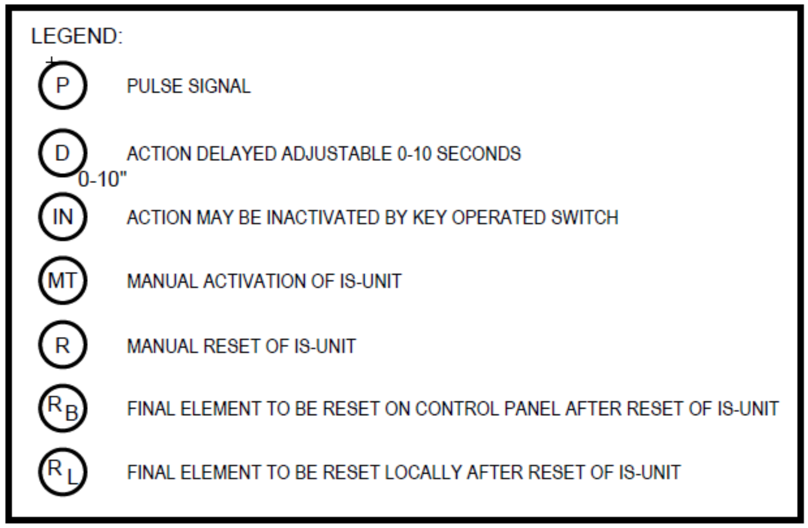
3.Interlock Blocks
- Tag of the Interlock
- Name of the interlock
- Manual trip
- Reset



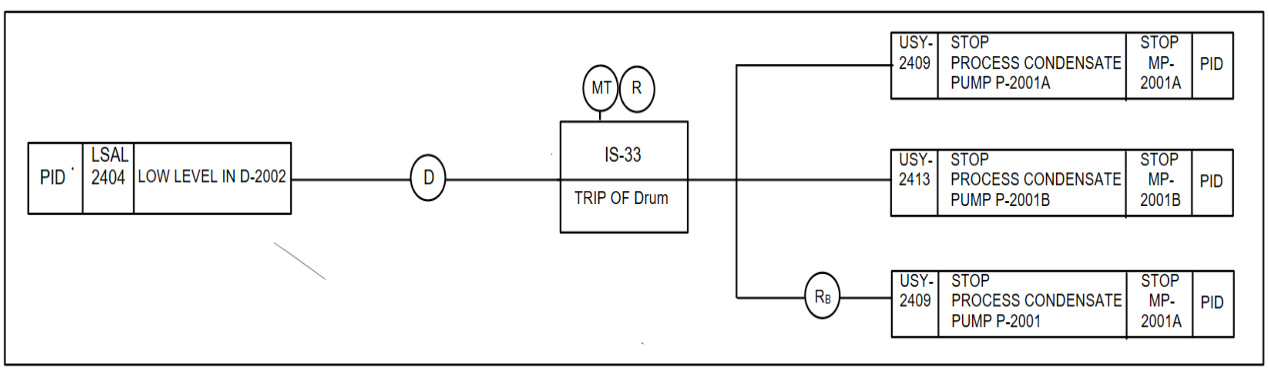
4.Actions
- Receiving element
- Action description
- Final Element
- P&ID Page



Note:



Now let's put them together:



Was it really difficult?

Now let's develop "Process Emergency Description" and "Interlock Diagram" for another application.

Example 2: Do you remember when we alluded to Auto-start of pumps during P&ID development. Then develop "Process Emergency Description" and "Interlock Diagram" for the above pump.

I-2001: Auto-start of standby pump P-2001

The causes for the auto-start of standby pump are:

- Low pressure downstream of P-2001

Note: The pumps should not be in tripped state.

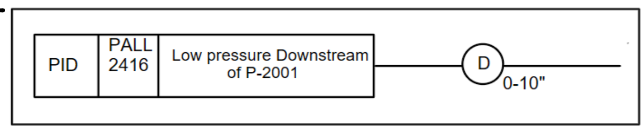
The following actions are carried out automatically:

- Start the pump P 2001 A, start MP-2001A
- Start the pump P 2001 B, start MP-2001B

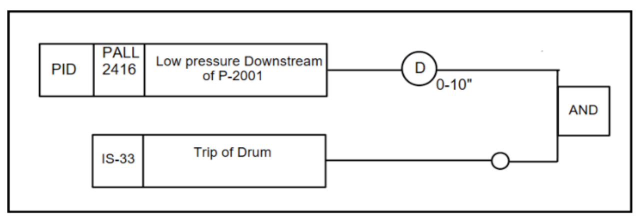
Now it is time to develop the Interlock Diagram.

To draw the interlock, we need to show the followings:

1.Causes



This example is different from previous one since here in note it is stated the pump should not be in tripped state, which means that the IS-33 should not be activated.



The ○ means Not.

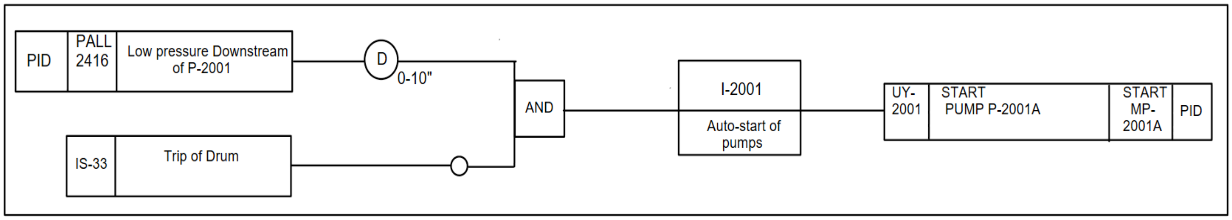
2.Interlock Blocks

I-2001
Auto-start of pumps

3.Actions

UY-2001	START PUMP P-2001A	START MP-2001A	PID

Let’s put them together.



Example 3: Do you remember the oxygen unit and how dangerous it is. You have learned from the gas station that when we want to introduce the gas to the plant, we need a big isolation valve and a small isolation valve. The reason why we have small isolation valve is to pressurize the system gradually and when the pressure in other side of the valve is in good shape, when can take action via big isolation valve. The same happens to the oxygen when it is introduced to the plant but since it is far dangerous than natural gas, we need to implement a control system for that to avoid any human error and as a result, any catastrophe.

How it works: At first, we open small isolation valve and slowly and slowly pressurize the system till the pressure reaches 20 barg and at that time the small isolation valve should be opened completely. Still the big isolation valve should be closed, which means that we should receive the feedback of ZLL. After receiving the confirmation, then we are allowed to reset and open the big isolation valve and pressurize the system.

Now imagine this scenario: we are in the middle of operation and an explosion occurs. The operation operator reaches the conclusion that the oxygen to the plant should be cut-off immediately. So there should be a Push Button [Manual Trip] to do so.

Now put the whole story together and look at it from another angle:

We are in the middle of the normal operation, the oxygen comes in and goes to the reactor and as a result, the Syngas is produced. Suddenly because of disturbance from utility company, we were made to cut-off the oxygen suddenly. The control room operator now presses the Manual Trip and closed the big and small isolation valves. After two days the unit being in a state of shut-down, we get the permission to introduce oxygen to our plants. At first, we open small isolation valve and slowly and slowly pressurize the system till the pressure reaches 20 barg and at that time the small isolation valve should be opened completely. Still the big isolation valve should be closed, which means that we should receive the feedback of ZLL. After receiving the confirmation, then we are allowed to reset and open the big isolation valve and pressurize the system.

Now we know the full story and let’s develop Interlock Diagram and the “Process Emergency Description”.

IS-23: Block oxygen from BL

The causes for trip are:

- Manual panel trip

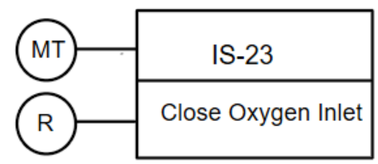
The following actions are carried out automatically:

- Block main oxygen line from BL, close HV-2003. HIC-2003 is automatically switched to manual mode with 0% output.
- Block bypass oxygen line from BL, close HV-2004. HIC-2004 is automatically switched to manual mode with 0% output.

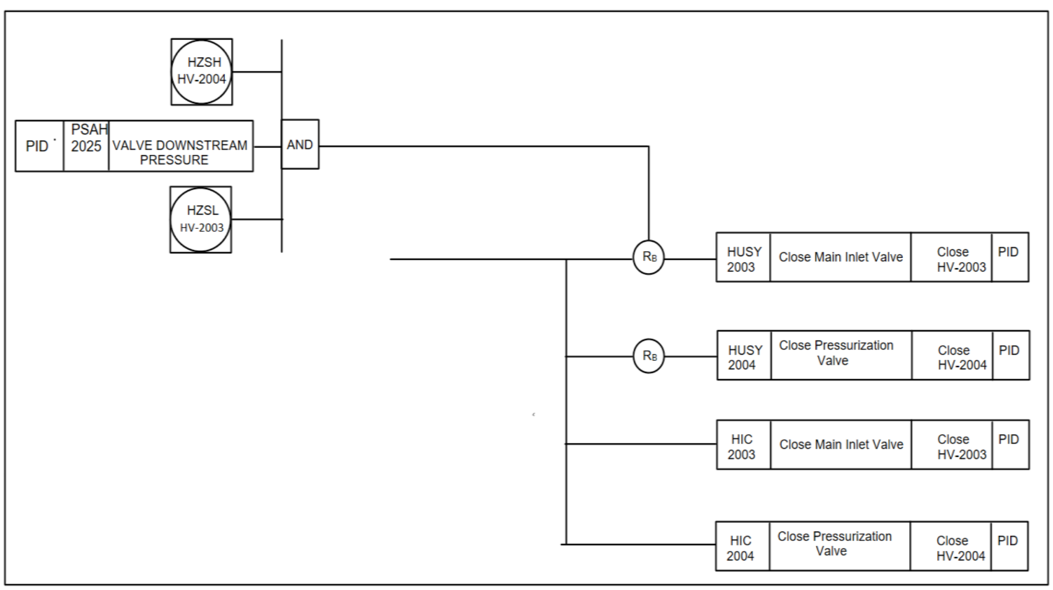
Before reset of the main oxygen valve from BL, the downstream side must be pressurized PSAH-2001, and bypass valve to be open HZSH-2004 and main valve closed HZSL-2003.

Let's focus on Interlock Diagram.

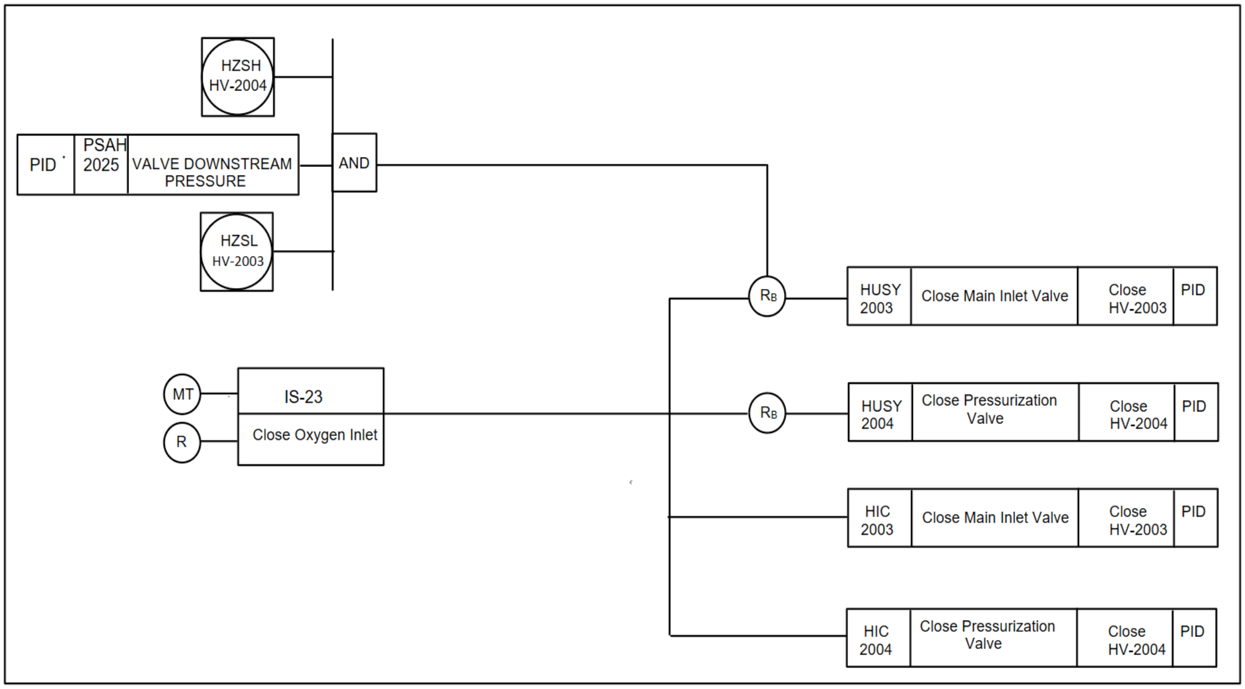
1.Causes and Interlock Block



2.Actions



Now put them together:


HZSH
HV-2004
PID
PSAH
2025
VALVE DOWNSTREAM
PRESSURE
AND
HZSL
HV-2003
RB
HUSY
2003
Close Main Inlet Valve
Close
HV-2003
PID
MT
R
IS-23
Close Oxygen Inlet
RB
HUSY
2004
Close Pressurization
Valve
Close
HV-2004
PID
HIC
2003
Close Main Inlet Valve
Close
HV-2003
PID
HIC
2004
Close Pressurization
Valve
Close
HV-2004
PID