**SCADA\_PRC\_PUMP\_3DUTY**

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| **Version** | **Release Notes** |
| 1.0 | Initial Release |

**Description**: This UDT is used for implementing duty rotation for three pumps.

**Naming Convention**: Tags will generally follow the naming convention BXX\_DTY#\_DP, where BXX denotes the facility and area and # is sequentially incremented for the number of duty rotation systems programmed in the PLC.

**UDT Members**

| **UDT Member** | **Datatype** | **Description** | **Usage** |
| --- | --- | --- | --- |
| ACP | Pump\_3Duty\_ACP\_v1 | Duty Pump ACP Control AOI | Used in Duty\_ACP routine of ACP Program |
| Alt | Pump\_3Duty\_Alt\_v1 | Duty Pump Alternation AOI | Used in Duty\_Alt routine ACP Program |
| In | Pump\_3Duty\_In\_v1 | Duty Pump Input Mapping AOI | Used in Duty\_In routine of ACP Program |
| Out | Pump\_3Duty\_Out\_v1 | Duty Pump Output Mapping AOI | Used in Duty\_Out routine of ACP program |
| DTY1\_STS | PRC\_Duty\_2\_3 | Duty Pump 1 Status and Control Bits | Used in PLC and HMI for Duty 1 Pump Status |
| DTY2\_STS | PRC\_Duty\_2\_3 | Duty Pump 2 Status and Control Bits | Used in PLC and HMI for Duty 2 Pump Status |
| DTY3\_STS | PRC\_Duty\_2\_3 | Duty Pump 3 Status and Control Bits | Used in PLC and HMI for Duty 3 Pump Status |
| PB\_SU | BOOL | ACP Setpoint Updates PB | Used on HMI |
| DI\_EE | BOOL | ACP Setpoint Entry Error | Used on HMI |
| PB\_AU | BOOL | Duty Pump Assignment Update PB | Used on HMI |
| DI\_UE | BOOL | Duty Pump Assignment Update Error | Used on HMI |
| AO\_EN | DINT | Duty Alternation Mode Selection | Used on HMI |
| AO\_DY | DINT | Duty Alternation Number of Days Setpoint | Used on HMI |
| AO\_HS | DINT | Daily Interval Rotation Hour Setpoint | Used on HMI |
| AO\_MS | DINT | Daily Interval Rotation Minute Setpoint | Used on HMI |
| AI\_TY | DINT | Daily Rotation Number of Days Remaining Setpoint | Used on HMI |
| AO\_AI | DINT | Hourly Rotation Hour Interval Setpoint | Used on HMI |
| AI\_EU1 | REAL | Span between start of duty pump 1 and duty pump 2 | Used on HMI |
| AI\_EU2 | REAL | Span between start of duty pump 1 and duty pump 3 | Used on HMI |
| AI\_EU3 | REAL | Span between start of duty pump 2 and duty pump 3 | Used on HMI |

The following table describes the PRC\_Duty UDT.

| **UDT Member** | **Datatype** | **Description** | **Usage** |
| --- | --- | --- | --- |
| SCALE\_CV | Scale\_FBD\_v2 | Speed Setpoint Calculation AOI | Used in Duty ACP AOI |
| Auto | BOOL | Duty Pump Auto Mode Status | Used internally in Duty AOIs |
| Fail | BOOL | Duty Pump has Failed Status | Used internally in Duty AOIs |
| Active\_Sts | BOOL | Duty Pump Running Status | Used internally in Duty AOIs |
| Auto\_Start | BOOL | Start Command | Used internally in Duty AOIs |
| Auto\_Stop | BOOL | Stop Command | Used internally in Duty AOIs |
| Auto\_Speed\_Setpoint | REAL | Speed Setpoint | Used internally in Duty AOIs |
| AI\_CT | DINT | Device Assigned to this duty | Used on HMI |
| AO\_CT | DINT | Device requested to be assigned this duty | Used on HMI |
| AO\_TS | REAL | Duty Start Setpoint Request | Used on HMI |
| AI\_TS | REAL | Duty Start Setpoint | Used on HMI |
| AO\_PS | REAL | Duty Stop Setpoint Request | Used on HMI |
| AI\_PS | REAL | Duty Stop Setpoint | Used on HMI |
| AI\_CV | REAL | Duty Speed Setpoint | Used on HMI |
| AI\_EU | REAL | Minimum Span between Start and Stop Setpoints | Used on HMI |
| AO\_XD | REAL | VFD Max Speed Elevation Request | Used on HMI |
| AI\_XD | REAL | VFD Max Speed Elevation | Used on HMI |
| AO\_ND | REAL | VFD Max Speed Elevation | Used on HMI |
| AI\_ND | REAL | VFD Min Speed Elevation Actual | Used on HMI |
| AO\_MN | REAL | VFD Min Speed Request | Can be used for Setpoint Entry on HMI if Min VFD Speed is Adjustable |
| AI\_MN | REAL | VFD Min Speed | Used for Speed Output Scaling in Duty AOI |
| AO\_MX | REAL | VFD Maximum Speed Request | Can be used for Setpoint Entry on HMI if Max VFD Speed is Adjustable |
| AI\_MX | REAL | VFD Maximum Speed | Used for Speed Output Scaling in Duty AOI |

**AOI**

| **AOI Parameter** | **Requirement** | **Default Value** | **Description** | **Implementation Guideline** |
| --- | --- | --- | --- | --- |
| Pump\_3Duty\_ACP\_v1 | Mandatory | *Tagname****.***ACP | Duty ACP Control AOI | N/A |
| Dty1\_Sts | Mandatory | *Tagname****.***DTY1\_STS | Duty 1 Status Tag | N/A |
| Dty2\_Sts | Mandatory | *Tagname****.***DTY2\_STS | Duty 2 Status Tag | N/A |
| Dty3\_Sts | Mandatory | *Tagname****.***DTY3\_STS | Duty 3 Status Tag | N/A |
| Duty\_Control\_CV | Mandatory | N/A | Device that controls start and stop of Duty Devices | This device is an analog instrument (typically a level transmitter) or setpoint whose value determines when duty devices should start and stop |
| Pumps\_on\_Backup | Optional | N/A | Pumps are on backup or hardwired control, disable ACP code execution | Map to a tag that indicates the duty pumps are no longer being controlled by the PLC |
| Custom\_Control | Optional | *Tagname*.ACP.Custom\_Control | Use Custom Control | Set to 1 if ACP control of duty pumps requires more complex or specialized control than an analog value being above or below setpoints |
| Duty\_1\_Start\_Rq | Optional | *Tagname*.ACP.Duty\_1\_Start\_Rq | Custom Control Duty 1 Start Request | Use when Custom Control Required and program outside of AOI |
| Duty\_1\_Stop\_Rq | Optional | *Tagname*.ACP.Duty\_1\_Stop\_Rq | Custom Control Duty 1 Stop Request | Use when Custom Control Required and program outside of AOI |
| Duty\_2\_Start\_Rq | Optional | *Tagname*.ACP.Duty\_2\_Start\_Rq | Custom Control Duty 2 Start Request | Use when Custom Control Required and program outside of AOI |
| Duty\_2\_Stop\_Rq | Optional | *Tagname*.ACP.Duty\_2\_Stop\_Rq | Custom Control Duty 2 Stop Request | Use when Custom Control Required and program outside of AOI |
| Duty\_3\_Start\_Rq | Optional | *Tagname*.ACP.Duty\_3\_Start\_Rq | Custom Control Duty 3 Start Request | Use when Custom Control Required and program outside of AOI |
| Duty\_3\_Stop\_Rq | Optional | *Tagname*.ACP.Duty\_3\_Stop\_Rq | Custom Control Duty 3 Stop Request | Use when Custom Control Required and program outside of AOI |

| **AOI Parameter** | **Requirement** | **Default Value** | **Description** | **Implementation Guideline** |
| --- | --- | --- | --- | --- |
| Pump\_3Duty\_Alt\_v1 | Mandatory | *Tagname*.ALT | Duty Alternation AOI | N/A |
| Dty1\_Sts | Mandatory | *Tagname*.DTY1\_STS | Duty 1 Status Information | N/A |
| Dty2\_Sts | Mandatory | *Tagname*.DTY2\_STS | Duty 2 Status Information | N/A |
| Dty3\_Sts | Mandatory | *Tagname*.DTY3\_STS | Duty 3 Status Information | N/A |
| Duty\_Alternation\_Selection | Mandatory | *Tagname*.AO\_EN | Duty Rotation Mode | N/A |
| Alternation\_Hour\_SP | Mandatory | *Tagname*.AO\_HS | Daily Rotation Hour at which to rotate | N/A |
| Alternation\_Minute\_SP | Mandatory | *Tagname*.AO\_MS | Daily Rotation Minute at which to Rotate | N/A |
| Alternation\_Days\_SP | Mandatory | *Tagname*.AO\_DY | Daily Rotation number of days between rotations | N/A |
| Alternation\_Hours\_SP | Mandatory | *Tagname*.AO\_AI | Hourly Rotation number of hours between rotation | N/A |
| Days\_Remaining | Mandatory | *Tagname*.AI\_TY | Daily Rotation Days Remaining | N/A |
| Duty1\_Duty2\_Span\_SP | Mandatory | *Tagname*.AI\_EU1 | Required Span between Duty 1 and Duty 2 Setpoints | N/A |
| Duty1\_Duty3\_Span\_SP | Mandatory | *Tagname*.AI\_EU2 | Required Span between Duty 1 and Duty 3 Setpoints | N/A |
| Duty2\_Duty3\_Span\_SP | Mandatory | *Tagname*.AI\_EU4 | Required Span between Duty 2 and Duty 3 Setpoints | N/A |
| WW\_Lvl\_Max | Mandatory | 100 | Maximum Wet well Level | Typically 100% but could be in metres or some other absolute measurement. For dynamic updating, map AO\_XM tag from control instrument. |
| Duty\_Assignment\_PB | Mandatory | *Tagname*.PB\_AU | Duty Assignments Pushbutton | N/A |
| Duty\_Assignment\_Error | Mandatory | *Tagname*.DI\_UE | Duty Assignment Entry Error | N/A |
| Duty\_Setpoints\_PB | Mandatory | *Tagname*.PB\_SU | ACP Setpoint Assignment Pushbutton | N/A |
| Duty\_Setpoints\_Error | Mandatory | *Tagname*.DI\_EE | ACP Setpoint Entry Error | N/A |
| SYS\_Calendar\_Hour | Mandatory | SYS\_Calendar\_This[3] | Current PLC Hour | N/A |
| SYS\_Calendar\_Minute | Mandatory | SYS\_Calendar\_This[4] | Current PLC Minute | N/A |
| First\_Scan | Mandatory | BXXPLC1.FIRST\_SCAN | First Scan Indicator | Replace with First Scan Tag Appropriate to PLC |

| **AOI Parameter** | **Requirement** | **Default Value** | **Description** | **Implementation Guideline** |
| --- | --- | --- | --- | --- |
| Pump\_3Duty\_In\_v1 | Mandatory | *Tagname*.IN | Duty Pump Inputs Mapping AOI | N/A |
| Dty1\_Sts | Mandatory | *Tagname*.DTY1\_STS | Duty 1 Status Information | N/A |
| Dty2\_Sts | Mandatory | *Tagname*.DTY2\_STS | Duty 2 Status Information | N/A |
| Dty3\_Sts | Mandatory | *Tagname*.DTY3\_STS | Duty 3 Status Information | N/A |
| Pump1\_Auto | Mandatory | DI\_AA tag of first pump | Pump 1 Auto Mode Status | Replace with Auto Tag of the first pump |
| Pump2\_Auto | Mandatory | DI\_AA tag of second pump | Pump 2 Auto Mode Status | Replace with Auto Tag of the second pump |
| Pump3\_Auto | Mandatory | DI\_AA tag of third pump | Pump 3 Auto Mode Status | Replace with Auto Tag of the first pump |
| Pump1\_Running | Mandatory | DI\_SS.eng tag of first pump | Pump 1 Running Status | Replace with running status Tag of the first pump |
| Pump2\_Running | Mandatory | DI\_SS.eng tag of second pump | Pump 2 Running Status | Replace with running status Tag of the second pump |
| Pump3\_Running | Mandatory | DI\_SS.eng tag of third pump | Pump 3 Running Status | Replace with running status Tag of the first pump |
| Pump1\_Failed | Mandatory | ADDON.Failed\_Alarm\_Status tag of first pump | Pump 1 Failed Status | Replace with a tag that indicates the first pump has failed and is not available to operate |
| Pump2\_Failed | Mandatory | ADDON.Failed\_Alarm\_Status tag of second pump | Pump 2 Failed Status | Replace with a tag that indicates the second pump has failed and is not available to operate |
| Pump3\_Failed | Mandatory | ADDON.Failed\_Alarm\_Status tag of third pump | Pump 3 Failed Status | Replace with a tag that indicates the first pump has failed and is not available to operate |

| **AOI Parameter** | **Requirement** | **Default Value** | **Description** | **Implementation Guideline** |
| --- | --- | --- | --- | --- |
| Pump\_4Duty\_Out\_v1 | Mandatory | *Tagname*.OUT | Duty Pump Outputs Mapping AOI | N/A |
| Dty1\_Sts | Mandatory | *Tagname*.DTY1\_STS | Duty 1 Status Information | N/A |
| Dty2\_Sts | Mandatory | *Tagname*.DTY2\_STS | Duty 2 Status Information | N/A |
| Dty3\_Sts | Mandatory | *Tagname*.DTY3\_STS | Duty 3 Status Information | N/A |
| Pump1\_Auto\_Start\_Request | Mandatory | ADDON.Auto\_Start\_Request of First Pump | Pump 1 Auto Start Command | If there are other auto-start conditions for the pump outside of duty control an intermediate tag must be used here |
| Pump1\_Auto\_Stop\_Request | Mandatory | ADDON.Auto\_Stop\_Request of First Pump | Pump 1 Auto Stop Command | If there are other auto-stop conditions for the pump outside of duty control an intermediate tag must be used here |
| Pump2\_Auto\_Start\_Request | Mandatory | ADDON.Auto\_Start\_Request of Second Pump | Pump 2 Auto Start Command | If there are other auto-start conditions for the pump outside of duty control an intermediate tag must be used here |
| Pump2\_Auto\_Stop\_Request | Mandatory | ADDON.Auto\_Stop\_Request of Second Pump | Pump 2 Auto Stop Command | If there are other auto-stop conditions for the pump outside of duty control an intermediate tag must be used here |
| Pump3\_Auto\_Start\_Request | Mandatory | ADDON.Auto\_Start\_Request of Third Pump | Pump 3 Auto Start Command | If there are other auto-start conditions for the pump outside of duty control an intermediate tag must be used here |
| Pump3\_Auto\_Stop\_Request | Mandatory | ADDON.Auto\_Stop\_Request of Third Pump | Pump 3 Auto Stop Command | If there are other auto-stop conditions for the pump outside of duty control an intermediate tag must be used here |
| Pump1\_Auto\_Speed\_Setpoint | Optional | *Tagname*.OUT.Pump1\_Auto\_Speed\_Setpoint | Pump 1 Auto Speed Setpoint | Map to Pump 1 ADDON.Auto\_Speed\_Setpoint tag if required |
| Pump2\_Auto\_Speed\_Setpoint | Optional | *Tagname*.OUT.Pump2\_Auto\_Speed\_Setpoint | Pump 2 Auto Speed Setpoint | Map to Pump 2 ADDON.Auto\_Speed\_Setpoint tag if required |
| Pump3\_Auto\_Speed\_Setpoint | Optional | *Tagname*.OUT.Pump3\_Auto\_Speed\_Setpoint | Pump 3 Auto Speed Setpoint | Map to Pump 3 ADDON.Auto\_Speed\_Setpoint tag if required |

**Typical AOI Operation Description**

When referring to these AOIs, it is important to delineate the difference between the pump number and the duty pump number. The pump number is a fixed value that is part of the tagname (4th character of fragment 3). The Duty Pump Number is a property of the pump indicating its starting and stopping priority in the execution of automatic code. For the purposes of code evaluation and execution in the PLC the pump number is assigned within the DTY*X*\_STS tag to indicate which pump is currently assigned that duty number.

**Pump\_3Duty\_In\_v1**

This AOI maps the current state of the pumps (auto mode, running status, and failure) to status tags within the duty pump structure, based on the current duty assignment of the pump.

**Pump\_3Duty\_Out\_v1**

This AOI maps automatic start, stop, and speed requests for a given duty pump to the actual field device, based on the current duty assignment of the pump.

**Pump\_3Duty\_ACP\_v1**

This AOI evaluates the logic conditions for starting and stopping the duty pumps and setting the speed of the duty pump. In Standard Control Mode (Custom\_Control = zero) an instrument value will start and stop the duty pumps as it moves between the various control setpoints. In custom control mode these start conditions are programmed outside of the AOI.

For a start command to be issued the duty pump must be in auto mode, not already running, the other duty pump must not be starting, and the system cannot be on backup mode. Additionally no start command will be issued for the duty 2 or duty 3 pumps if they have failed.

For a stop command to be issued the duty pump must be running and not in backup mode.

The speed command for each duty pump is calculated using the scaling FBD AOI, where the instrument reading is the “raw” value and is scaled to the min and max speeds according to its relative position within the elevation setpoints. The speed clamped so that it is within the minimum and maximum speed limits.

**Pump\_3Duty\_Alt\_v1**

The Duty Alternation AOI validates manual duty assignment and ACP setpoints, and controls automatic duty rotation.

On first scan, if the duties are outside of a valid range, assign Pump 1 to Duty 1, Pump 2 to Duty 2, and Pump 3 to Duty 3.

The AOI will then evaluate manual duty assignment. The only check on manual duty assignment is that the pump assignments to each duty must be unique. If this check fails, then an error occurs the setpoints are not updated. Otherwise, the new duty assignments will be applied.

The AOI will then evaluate ACP setpoints. The following validation is performed:

The difference between the Start and Stop Setpoints for a given Duty Pump must be positive and greater than or equal to an allowable span programmed in the PLC. The Difference between the start setpoints (1-2,1-3, 2-3) must also be positive and greater than or equal to the allowable span programmed in the PLC.

The Start and Stop Setpoints for a given duty pump must be unique, and the Duty 1, Duty 2, and Duty 3 start setpoints must be unique.

The stop setpoint for a given duty must be less than or equal to the stop setpoints for each successive duty pump (e.g. Duty 1 stop setpoints must be less than the stop setpoints for the duty 2 and duty 3 pumps). **Note that the stop setpoints do not need to be unique**.

The Minimum Speed elevation for a duty pump must be greater than or equal to the stop setpoint for the duty pump.

The Maximum Speed Elevation must be greater than or equal to the Minimum Speed Elevation.

The Maximum Speed Elevation of a duty pump must not exceed the start setpoint for the next duty pump in sequence.

The Maximum Speed Elevation for Duty Pump 4 must not exceed the maximum reading of the control instrument.

Provided **all** these conditions are met when the update pushbutton is pressed, the setpoints will be updated. Otherwise, an error will be posted to the HMI.

**If Speed Elevation Control is not being used**, the programmer must write logic outside the AOI to set the speed elevation setpoints in the following manner:

The Min Speed Elevation for the Duty Pump must be equal to the stop setpoint of the duty pump

The Max Speed Elevation for the Duty Pump must be equal to the start setpoint for the Subsequent Duty Pump. For Duty Pump 3 the Max Speed elevation should be equal to WW\_Lvl\_Max.

The AOI will then begin evaluating automatic duty cycle requests. If duty rotation is configured for all pumps being stopped, then a duty rotation request will be made when all pumps return to the stopped state.

The next evaluation is the daily rotation. The operator has the option of configuring the time at which the rotation occurs from SCADA. When the time is reached, the day counter is incremented by 1. When the number of days between rotations is reached, a duty rotation request is made.

The system will then evaluate the hourly duty rotation. A free running hour counter increments the hourly interval counter by 1. When the interval is equal to the hours between rotation setpoint, a duty rotation request is made.

The logic will then process the duty rotation requests. For automatic duty rotation to occur, duty rotation must not be disabled, and all pumps must be in auto. Provided these conditions are met, the duties will rotate as requested.

The system then evaluates if either duty 1 or duty 2 pumps have failed. Provided that at least one of the backup pumps is available, the system initiates a duty rotation.

Whenever a duty rotation (manual, automatic, or on pump failure) is made, the PLC will set a bit to inhibit any further duty rotations. This allows the duty pump state assignments to be updated prior to making any additional logic evaluations. Thus, only one duty rotation can occur per scan. If additional rotation assignments are to be made (e.g. due to pump failure) it will occur on subsequent scans of the PLC after updating the duty pump state information. Note that it may take several scans to rotate an available pump to a higher priority duty assignment if there are multiple failed pumps.

The remaining rungs of the AOI reset counters, timers, and pushbuttons associated with the AOI.

**Programming Guide**

In addition to a three pump duty rotation, this AOI may be used to implement a standby pump system by hard coding Duty 3 setpoints in the PLC so that they will not result in an entry error being generated when the other setpoints are updated by the operator. Custom Control may then be used in the ACP AOI to inhibit automatic starting and stopping of the duty 3 pump and replicating the analog instrument start/stop conditions outside of the AOI.

**HMI Integration**

This UDDT is associated with the following screens in the InTouch baseload

* Pumping Station Setpoints
* Pumping Station Limits
* 3Device Duty Select
* Duty Rotation

The “Pumping Station Setpoints” and “Pumping Station Limits” screens are templates that will be renamed and customized based on the application, specifically the number of installed pumps, whether or not there is a standby pump, whether or not there is feedback control on the speed etc. The remaining two screens are common pop-up elements that use indirect mapping to the appropriate controls to set the pump duty assignments and duty rotation. Programmers shall perform appropriate search and replace operations on screen objects to update the tag names applicable to the application. Customization of the Duty Assignment Action script (The blue bar on the Setpoints pop-up) will be required based on the application.