

S&C Compressor Surge Prevention Control Solution

### (Patent # US 10,254,719)

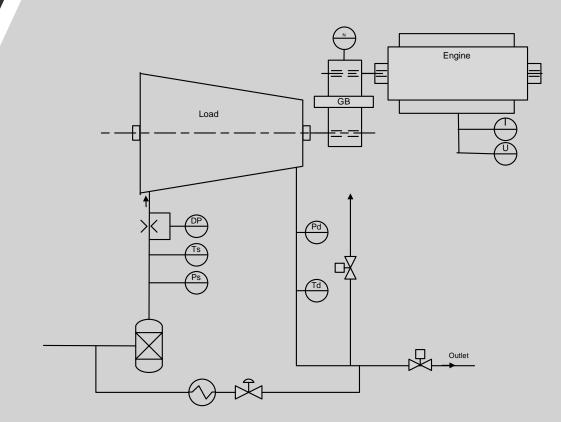
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### Turbomachinery Control Solutions Overview

Solutions for all variations of turbomachinery equipment

- Steam Turbine & Extraction Control
- Surge Prevention Control
- Gas Turbine Control
- Reciprocating Unit Control
- Compressor Group Station Control
- Power Generation Unit and Station Control

Solutions for all third-party hardware & software platforms compliant with IEC 61131





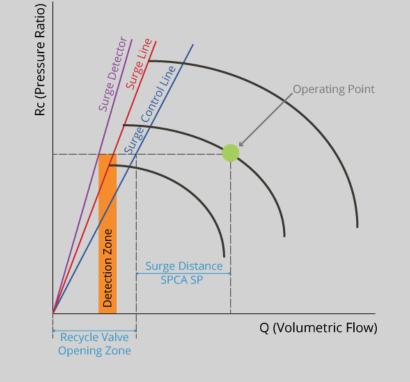
### Surge Prevention Control

Surge Prevention Control Application (SPCA)

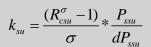
- Controls gas flow through compressor
- Defines the surge line and other operating lines over a wide range of changing conditions
- Uses two levels of PID control to operate surge control valve
- Calibrated using manufacturer specification and compressor maps or through field testing

#### Benefits

- Simplify calibration by recording surge events and conditions and by automatically defining parameters
- Balance surge control valve opening and closing to avoid surge but not waste power
- Use algorithms to determine how the surge limit changes as the process conditions change



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$$SP_{su} = dP_{ssu} * CLM = \frac{(R_c^{\sigma} - 1)}{\sigma} * \frac{Ps}{k_{su}} * CLM$$

## Multistage Compressor Applications

Ethylene Plant:

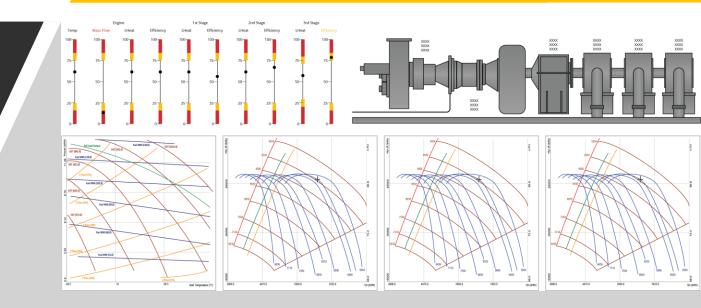
- Cracked gas compressor train, 4 or 5 stages, two recycle lines, driven by extraction turbine
- Propylene refrigerant compressor train, 4 sections with side streams, driven by steam turbine
- Ethylene refrigerant compressor train, 3 sections with side streams, driven by steam turbine

Urea Plant:

CO2 Compressor train, 4 stages, one recycle lines, driven by extraction turbine

Ammonia Plant:

- Process Air Compressor. 2 or 3 stages, one blow off valve, usually driven by condensing turbine or an electric motor
- Syn Gas Compressor, 4 or 5 stages, driver is a steam turbine
- Ammonia Refrigeration Compressor, 2 or 3, driven by extraction turbine





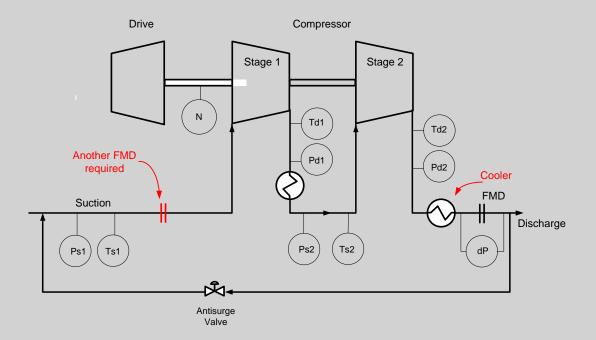
### Traditional Control Design Problems

#### Typical Situation:

- One FMD per unit
- Cooler between FMD and compressor stage
- One recycle valve per unit
- Multiple Surge Controllers

#### Typical Problems:

- Inaccurate surge limit calculation for each stage
- Large surge safety margin
- No adequate surge protection



Traditional approach requests that a cooler should not exist between the flow element and the compressor stage it services

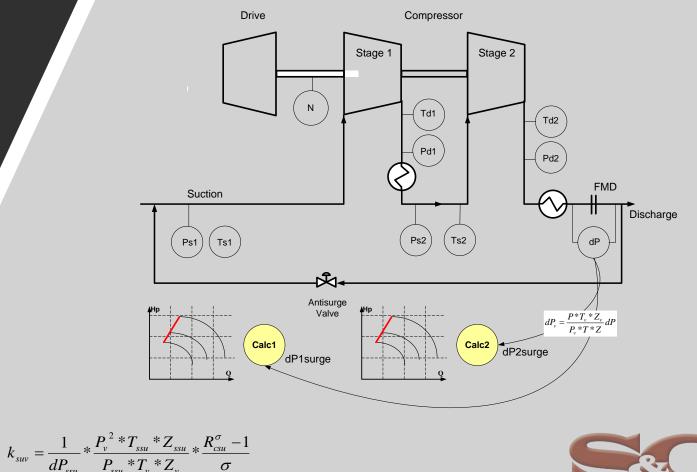
Traditional approach requests the flow element must be provided for each compression stage protected by an antisurge controller



## S&C Algorithm, Step 1

S&C method accurately calculates of surge limit line for overall multistage compressor using one available flow measuring device:

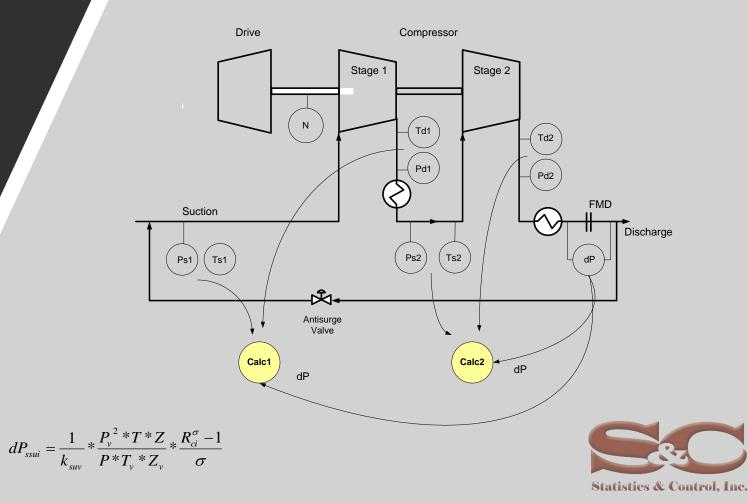
- If flow measuring device is not located in suction of compressor stage first algorithm converts flow to suction condition. It calculates virtual flow measurements for stages with no FMD.
- Each stage calculation algorithm is calibrated using manufacturer specification and compressor maps or through field testing. Surge limit line of each stage is computed via one available FMD.





## S&C Algorithm, Step 2

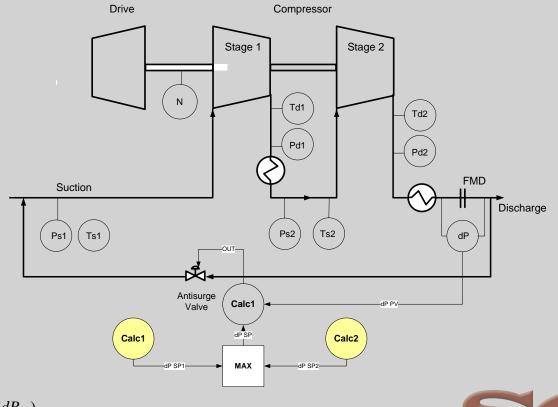
- Controller measures pressure suction, pressure discharge, temperature suction, temperature discharge, and speed for each stage.
- Each stage differential pressure surge limit set point calculated for current operating conditions as a function of calibration and current measured pressures and temperatures.



# S&C Algorithm, Step 3

This method focuses on reliable Surge Prevention control of entire multistage compressor while simplifying the control system configuration and minimizing interaction between control modules.

- Controller computes overall compressor surge limit set point for current operating conditions by selecting maximal value of all computed individual stages surge limit set points.
- PID controller comperes current measured dP with computed overall compressor surge limit set point and modulating antisurge control valve based on comparison for compressor surge prevention.



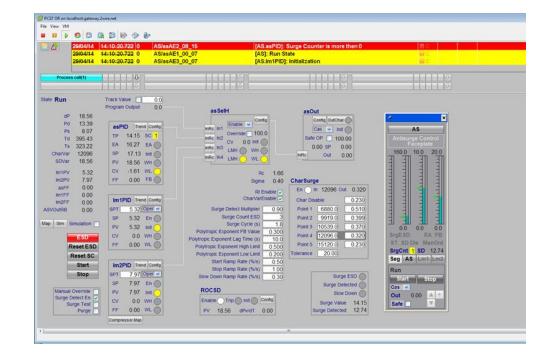
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 $dP_{sp} = MAX(dP_{spi})$ 

Hardware and Software Independent Control Platform

Now you can control your rotating equipment with the same control platform as the plant with tested, flexible, and competitive solutions and reduce support and maintenance costs

AntiSurge Control Point Detail								
AS4	Main Loop Tune	Surge	Test	PV, SP, OP	A larm s	Connections	Chart	
Antisurge Control	Execution & Control				Alarm Enable & Sum			
, and go control	Execution State	ACTIVE			Alarm Enable State	Enabled		
R	Load State		READY		Journal Only Option			
50.0 100 100	CEE State		RUN		Surge Count ESD		SelH Safety Interlock	
	Order in CEE	Order in CEE 20			External ESD		SelH Bad Control	
	Execution Period		50m S		Surge Detected		AS Safety Interlock	
	Execution Phase		0		Rate of Change Tr		AS Bad Control	
	Control Level		200		Enhanced Action		Lim1 Safety Interlock	
	Control Confirmation				Falback		Lim1 Bad Control	
	Manual Override OFF	Reset S	OFF		Slow dow n		Lin2 Safety Interlock	
0.00 0.00 0.00		-		_	Surge Detect Disal	e O	Lim2 Bad Control	
	Purge OFF	Reset E	SD OFF	-	Manual Override		Tuning	
×					•	-	Surge Test	
SrgCnt ()	Selector Mode CAS	Mode Attribut	e P	ROGRAM	Differential Pressure		18.209	
D 7.011 EA 8.413		Limt	Lim2		Discharge Pressure (a	bs)	70.198	
See AC Limit Limit	Normal Mode		- CAS		Suction Pressure (abs	)	58.250	
Seq AS Lim1 Lim2	Normal Mode Attribute		- NONE		Discharge Temperatur	e (K) 3	17.395	
OpenLoop None -			PERMIT	200	Suction Temperature (	K) 3	01.477	
	Permit Operator Mode Changes	PERMIT			Compressor Ratio		1.205	
SelH			• NOTPE		Polytropic Head Expon		0.300	
DP 50.75 %	Enable External Mode Changes	DISABLE	DISABL	E 💌	Characterizer Variable	67	00.000	
					QVCS information			
CAS -	Assigned Controller							



### **Process Control**

- Increased process reliability
- Reduced start-up time
- Reduced product waste
- Improved process control
- Reduced energy consumption
- Improved stability
- Reduced maintenance cost
- Reduced capital cost

Unit Control System

- Improved surge protection
- Larger operating envelope without recycle
- Optimum control during start-up
- Single supplier solution
- OEM neutral
- Hardware and software independent control platform
- Integrated compressor and turbine control system

# Benefits