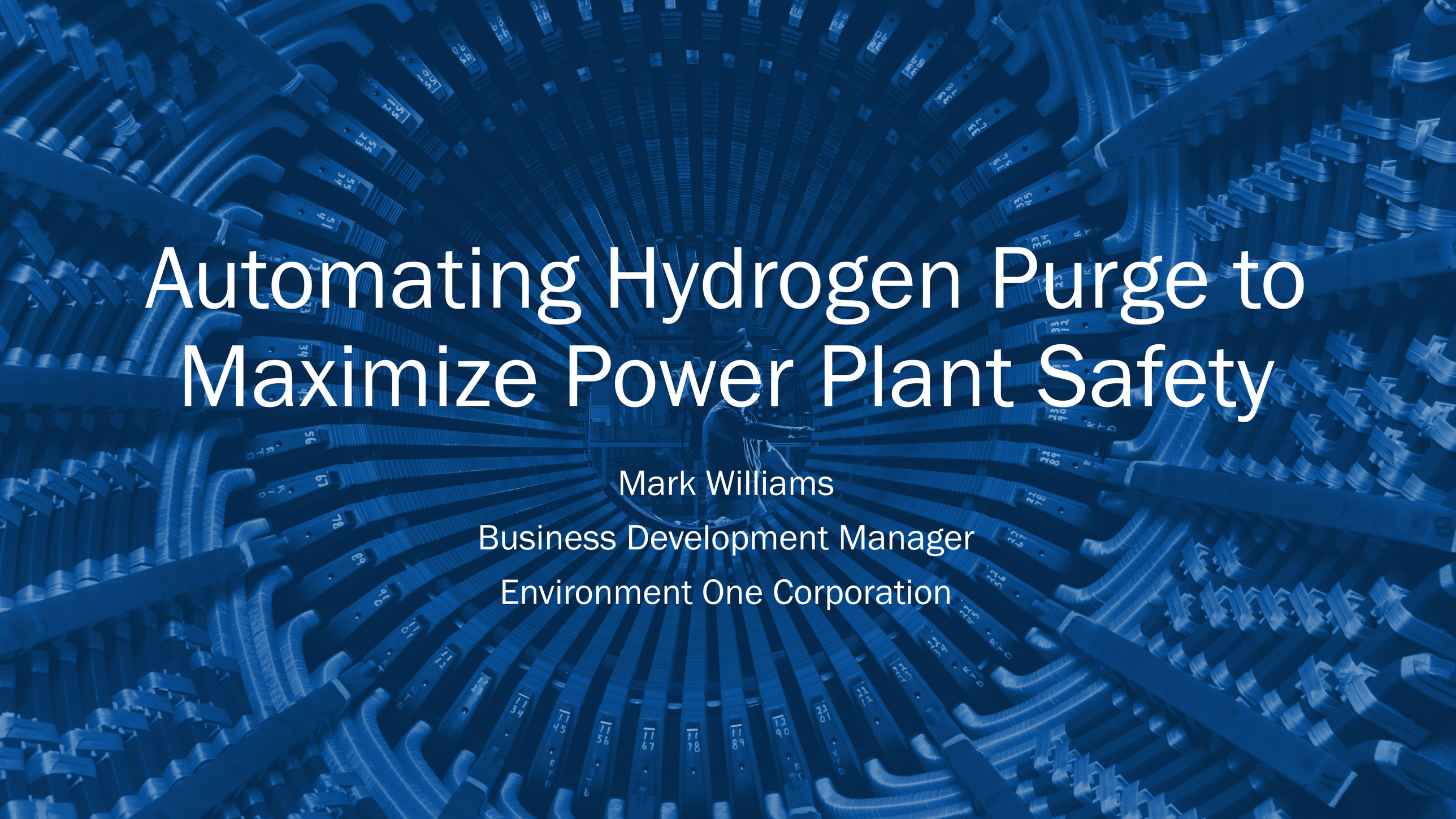


Automating Hydrogen Purge to Maximize Power Plant Safety

Mark Williams

Business Development Manager

Environment One Corporation

Program Outline

- What is a Remote Operator-Initiated purge system?
- Benefits of an automated purge system
- What do we need to know to get started?
- Options for automating your purge
- Connection points
- 7F automation kit
- CO_2 vaporizer

Operator-Initiated Remote Purge

Operator-Initiated Automated Generator Purge

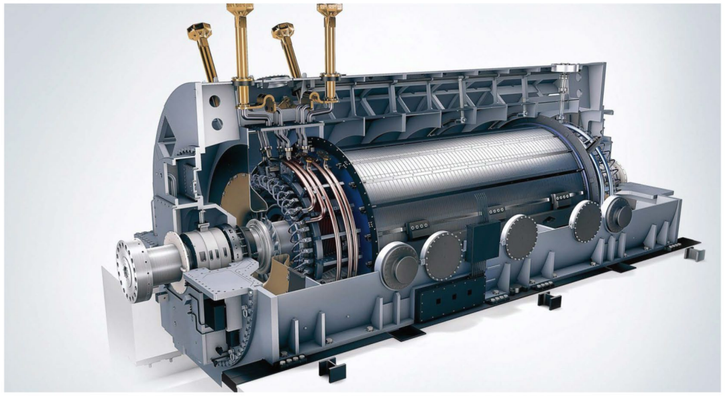
What Are The Benefits

- The same process every time no matter who is doing it.
- If there is an emergency there is no need to go in harm's way.
- It will speed up the time a purge takes with the correct equipment and process.

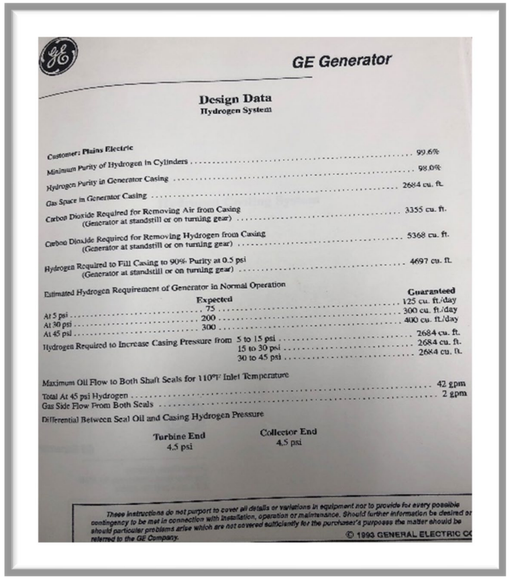
Are You Facing CO_2 Purge Issues?

- How long is it taking to purge your generator 6, 8, 10, 12 hours?
- How much CO_2 are you going through for each purge?
- Are you using CO_2 bottles or bulk tanks, gas or liquid CO_2?
- Are you using more than 2-3 full case volumes of gas to complete a purge from H_2 to CO_2?
- Do you have a way to confirm the flow rate and the total amount of CO_2 that has flowed to the generator?
- What is the condition of your CO_2 regulators, are they in good functional condition?
- What CO_2 pressure and flow rate are you using to purge?
- Based on the frequency of purges do you feel your operators have a good understanding of the process and are well trained?

What We Need to Know



Generator Case



GE Generator

Design Data
Hydrogen System

Customer: Plains Electric

Minimum Purity of Hydrogen in Cylinders	99.6%
Hydrogen Purity in Generator Casing	98.0%
Gas Space in Generator Casing	2684 cu. ft.
Carbon Dioxide Required for Removing Air from Casing (Generator at standstill or on turning gear)	3355 cu. ft.
Carbon Dioxide Required for Removing Hydrogen from Casing (Generator at standstill or on turning gear)	5368 cu. ft.
Hydrogen Required to Fill Casing to 90% Purity at 0.5 psi (Generator at standstill or on turning gear)	4697 cu. ft.

Estimated Hydrogen Requirement of Generator in Normal Operation

	Expected	Guaranteed
At 5 psi	75	125 cu. ft./day
At 30 psi	200	300 cu. ft./day
At 45 psi	300	400 cu. ft./day
Hydrogen Required to Increase Casing Pressure from 5 to 15 psi		2684 cu. ft.
15 to 30 psi		2684 cu. ft.
30 to 45 psi		2684 cu. ft.

Maximum Oil Flow to Both Shaft Seals for 110°F Inlet Temperature	42 gpm
Total At 45 psi Hydrogen	2 gpm
Gas Side Flow From Both Seals	

Differential Between Seal Oil and Casing Hydrogen Pressure

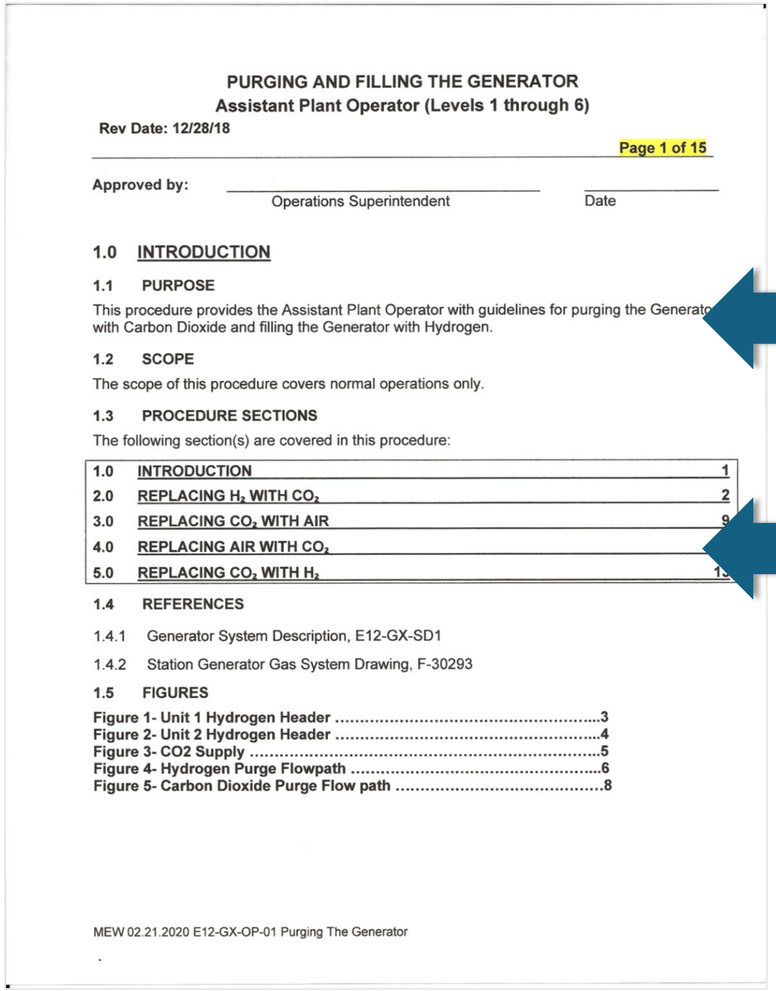
Turbine End	Collector End
4.5 psi	4.5 psi

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes the matter should be referred to the GE Company.

Generator Case Volume

CO_2 Storage

Review of Your Purge Procedure



PURGING AND FILLING THE GENERATOR
Assistant Plant Operator (Levels 1 through 6)

Rev Date: 12/28/18

Approved by: _____ Operations Superintendent _____ Date

1.0 INTRODUCTION

1.1 PURPOSE

This procedure provides the Assistant Plant Operator with guidelines for purging the Generato
with Carbon Dioxide and filling the Generator with Hydrogen.

1.2 SCOPE

The scope of this procedure covers normal operations only.

1.3 PROCEDURE SECTIONS

The following section(s) are covered in this procedure:

1.4 REFERENCES

1.4.1 Generator System Description, E12-GX-SD1

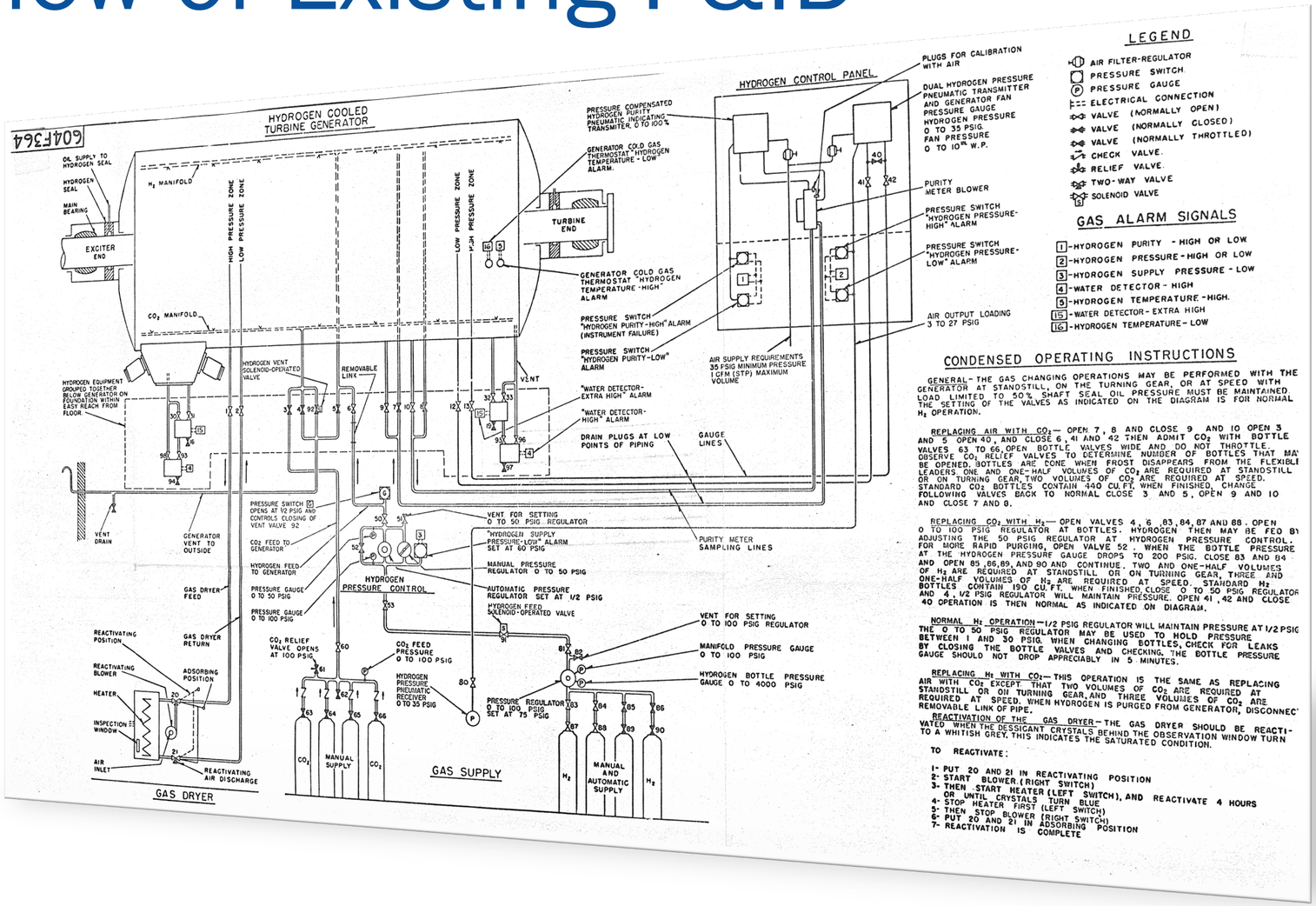
1.4.2 Station Generator Gas System Drawing, F-30293

1.5 FIGURES

Introduction

Procedures

Review of Existing P&ID



Review Existing Gas Manifold to Identify Needed Piping and Tag Needed Tie In Points

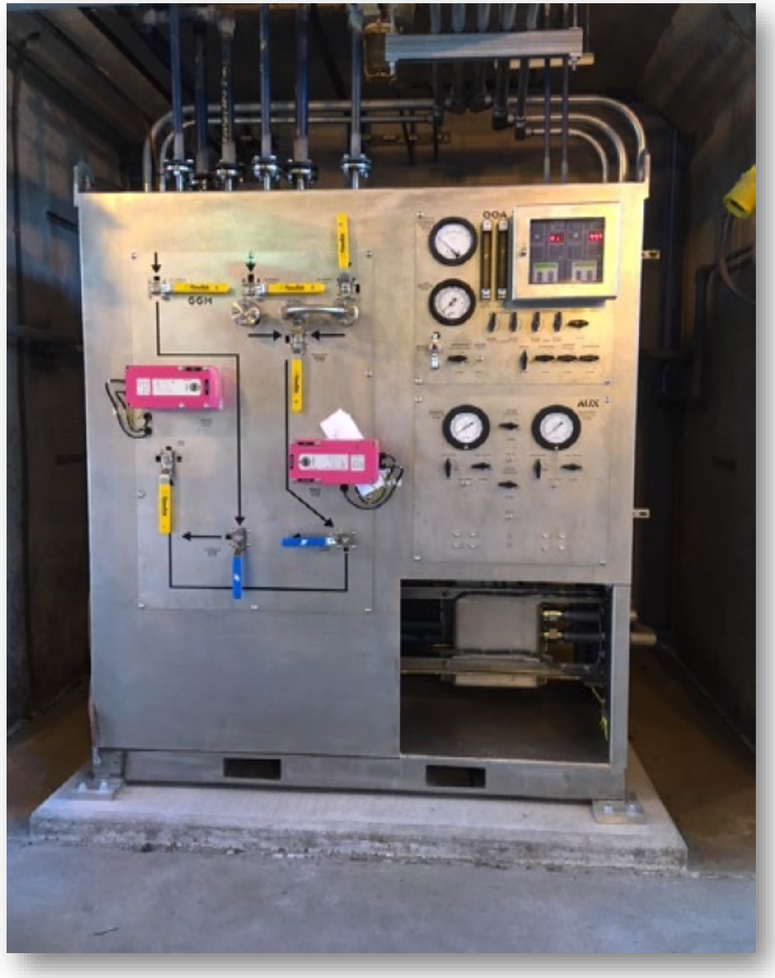
Review Existing CO_2 Bottle Rack

Automated Purge System Options

Remote Automation Panel

Stand Alone Automated Gas Manifold

Automated Purge System Options



Gas Station with:

- Online redundant H_2 analyzers
- Case pressure
- DP pressure gages and transmitters
- H_2 supply & CO_2 pressure gages and transmitters
- Fully manual & automated gas manifold with online monitoring of purge gases

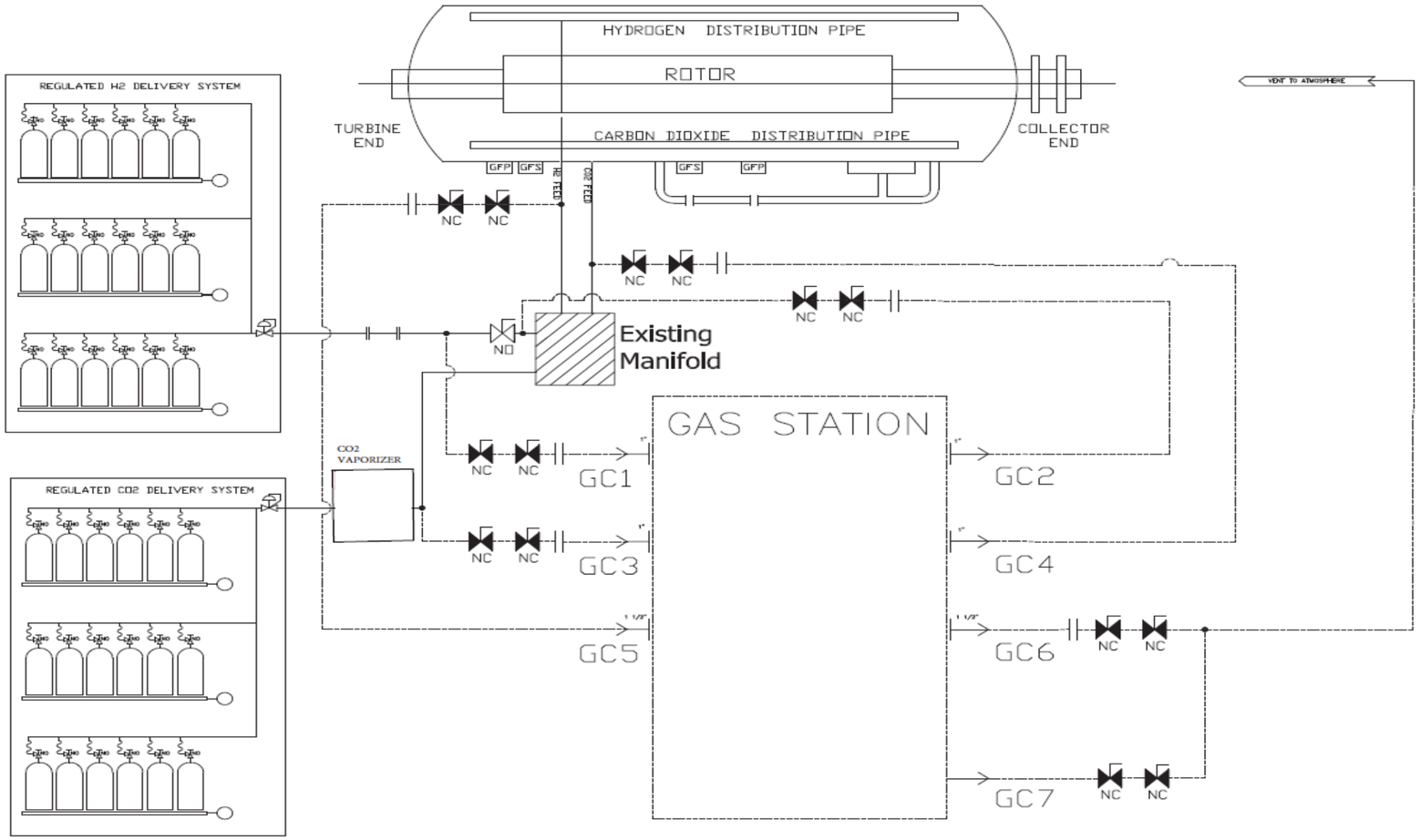
Options For Automating Purge Process

- Rotary actuators with 4-20 mA feedback/switches
- Solenoid valves with check valves
- Gages & transmitters for supply gasses
- CO_2 flow meter/transmitter 4-20mA
- Installed explosion proof H_2 analyzer with remote range change capability

Tie In Points

1. Top Header
2. Bottom Header
3. Fan Pressure & Suction
4. CO_2 Supply Line
5. H_2 Supply Line
6. Vent Line
7. H_2 Analyzer Connection at the Vent Line

Automated Purge System Generator Tie In Points



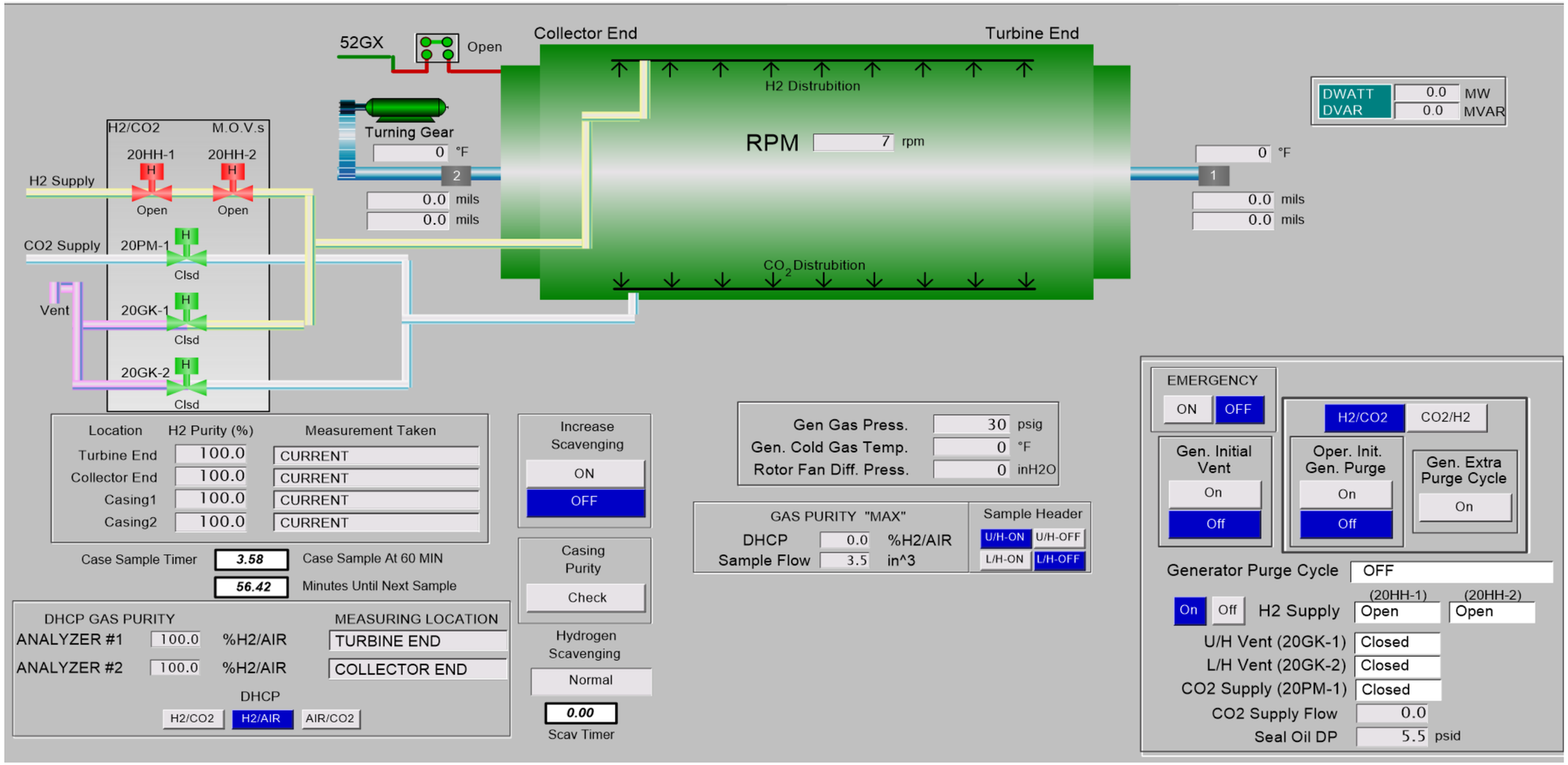
7F Automated Purge System Kit

- DHCP Enhanced Purge software and electronics
- Remote range change from H_2 in air to H_2 in CO_2 and CO_2 and air
- 1 SS marshalling box
- Indicating transmitter for seal oil system
- 3 SCHISCHEK EXM ACTUATOR with 1" ball valve & mounting hardware
- 2 SCHISCHEK EXMAX ACTUATOR with 2" ball valve & mounting hardware

Rotary Actuators, Valves, and Analyzer Tie in Points

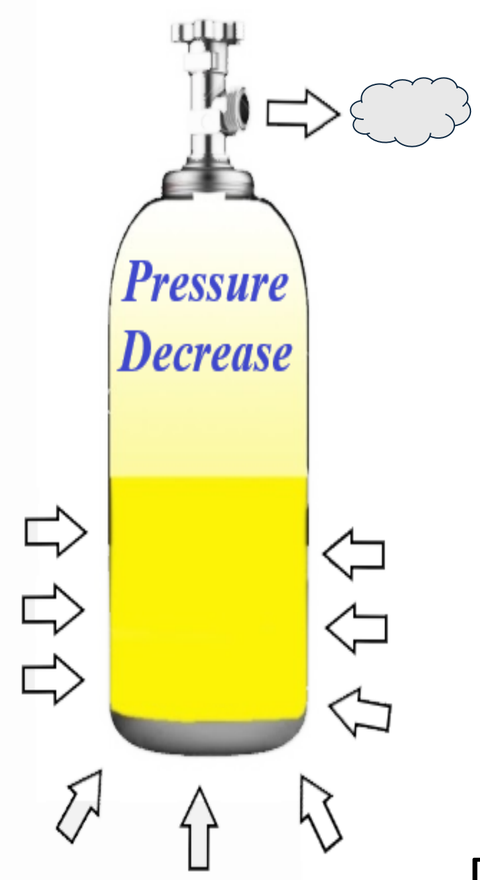
Removal of the four existing Clark Cooper control valves & replacement with rotary actuators and valves for H_2 line, CO_2 line, vent line and top or bottom header pipe selection and addition of an additional SS junction box.

Example of an Automated Purge Screen



Liquified Compressed CO_2 Supply

- When we remove vapor/gas from the cylinder, the pressure in the cylinder is reduced
- This will cause the liquid to change to a gas phase resulting in cooling
- To restore equilibrium the cylinder needs to absorb more energy from the environment
- When dry ice is formed 30% or more CO_2 is lost in each bottle



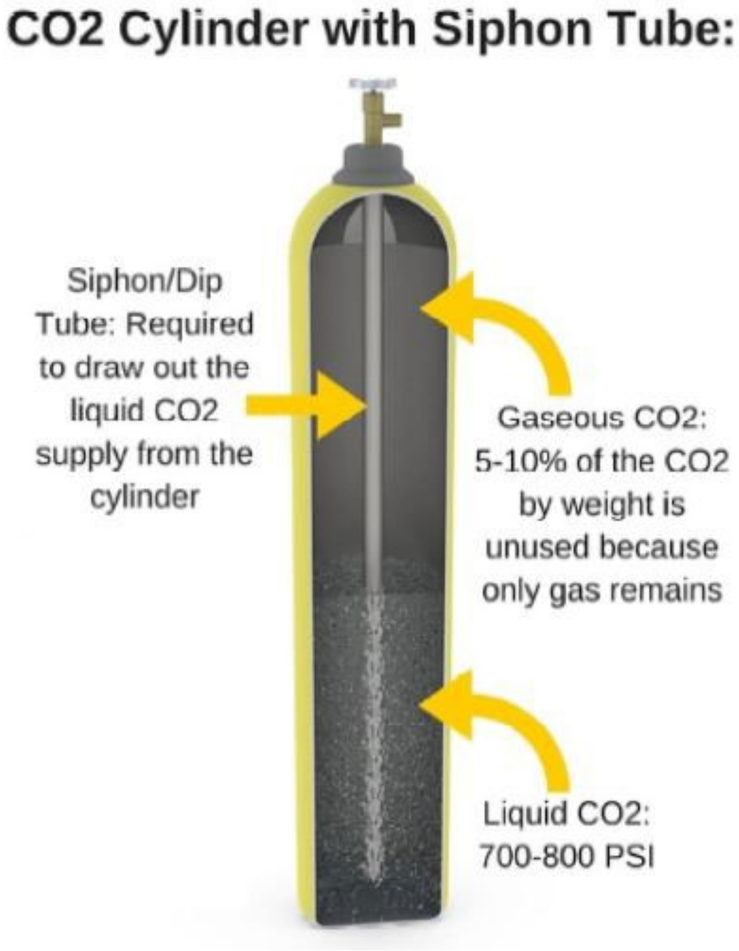
Dry Ice formation

Liquid CO_2 Supply

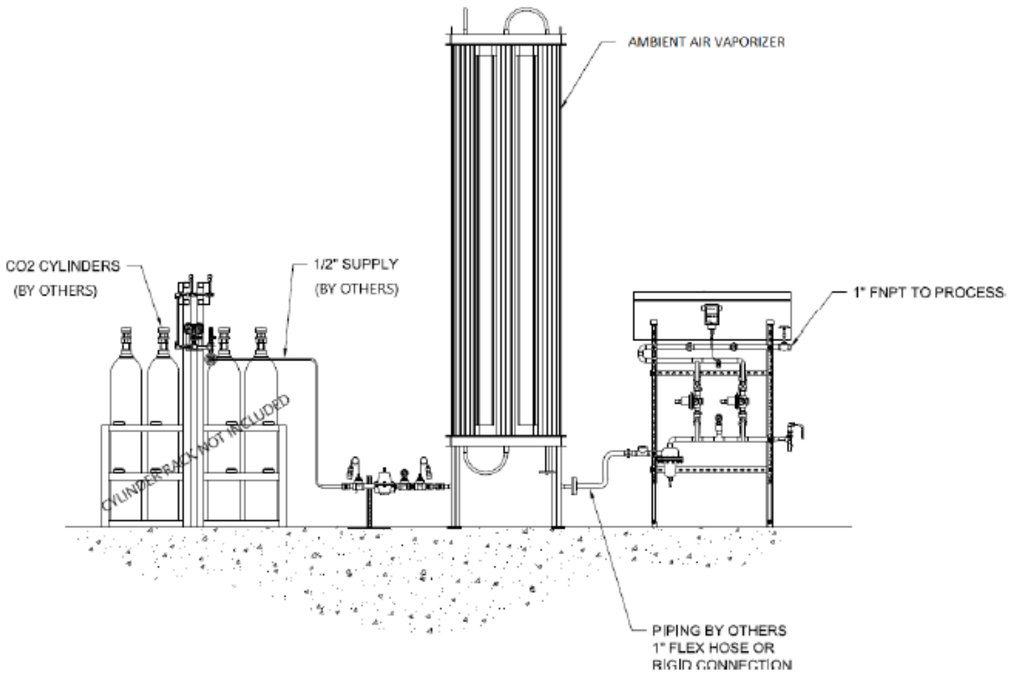
Dip Tube Syphon/Tube Cylinder

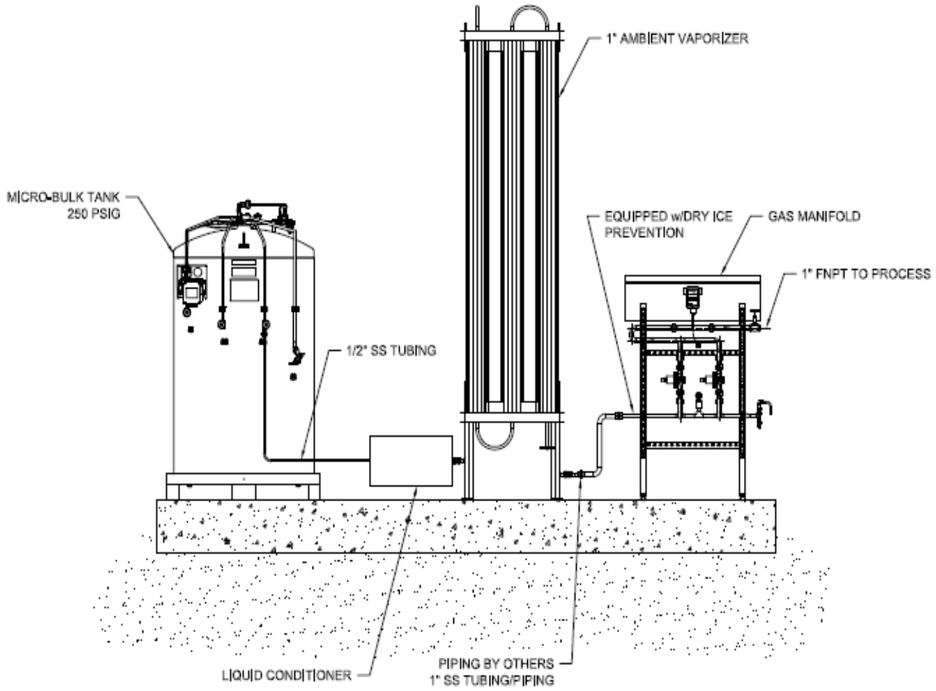
Because the amount of vapor that must be produced is small, the effect on temperature is minimized

- Removal rate from cylinder is remains high
- This enables 90% - 95% of CO_2 usage
- 5-10% Residual CO_2 will exist due to dip tube length



TurbinAL Non-Powered Vaporizer





TurbinAL CO_2 Vaporizer Supply System Overview

- Fast degas/purge non-powered vaporization
- Design ensures gas phase delivery without the concern of forming dry ice
- True hands-free system operation
- Flow Rate and Total Flow indication (120VAC Powered)
- Delivery Pressure Control @ 40-60 psig

Installed TurbinAL Vaporizer

Operator-Initiated Automated Purging

Jason Justice

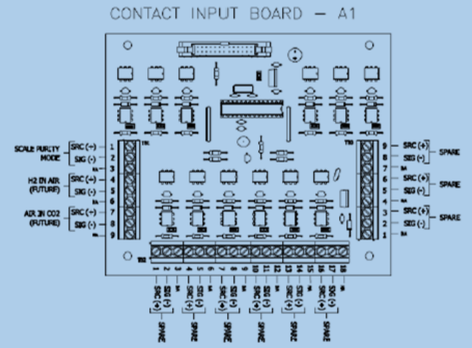
Consulting Engineer

J3 Engineering & Construction

DHCP Remote Gas Selection Monitoring Enhancement

The enhancement requires:

1. DHCP I/O board along with modifications to the existing DHCP firmware
   a. Below I/O board shown below for reference only.



2. Wiring changes to utilize the I/O board
   a. Contact Input – Qty. 1
   b. Relay Output – Qty. 2
3. Modification of the existing turbine controls software.

1. Original Solenoid valves replaced with MOVs (20HH-1, 20HH-2)
2. Flowmeter installed to ensure analyzer has acceptable sample flow. (DPT-201)
3. SV-1, SV-2 added to direct sample gas flow from appropriate generator header
4. MOV 20GK-2 installed to enable purging from bottom generator header when appropriate.

<u>Especially Beneficial for “Operator-Initiated Purge”</u>

Operator-Initiated Purge: Enhancements

1. Original Solenoid valves replaced with MOVs (20HH-1, 20HH-2)
2. Flowmeter installed to ensure analyzer has acceptable sample flow (DPT-201)
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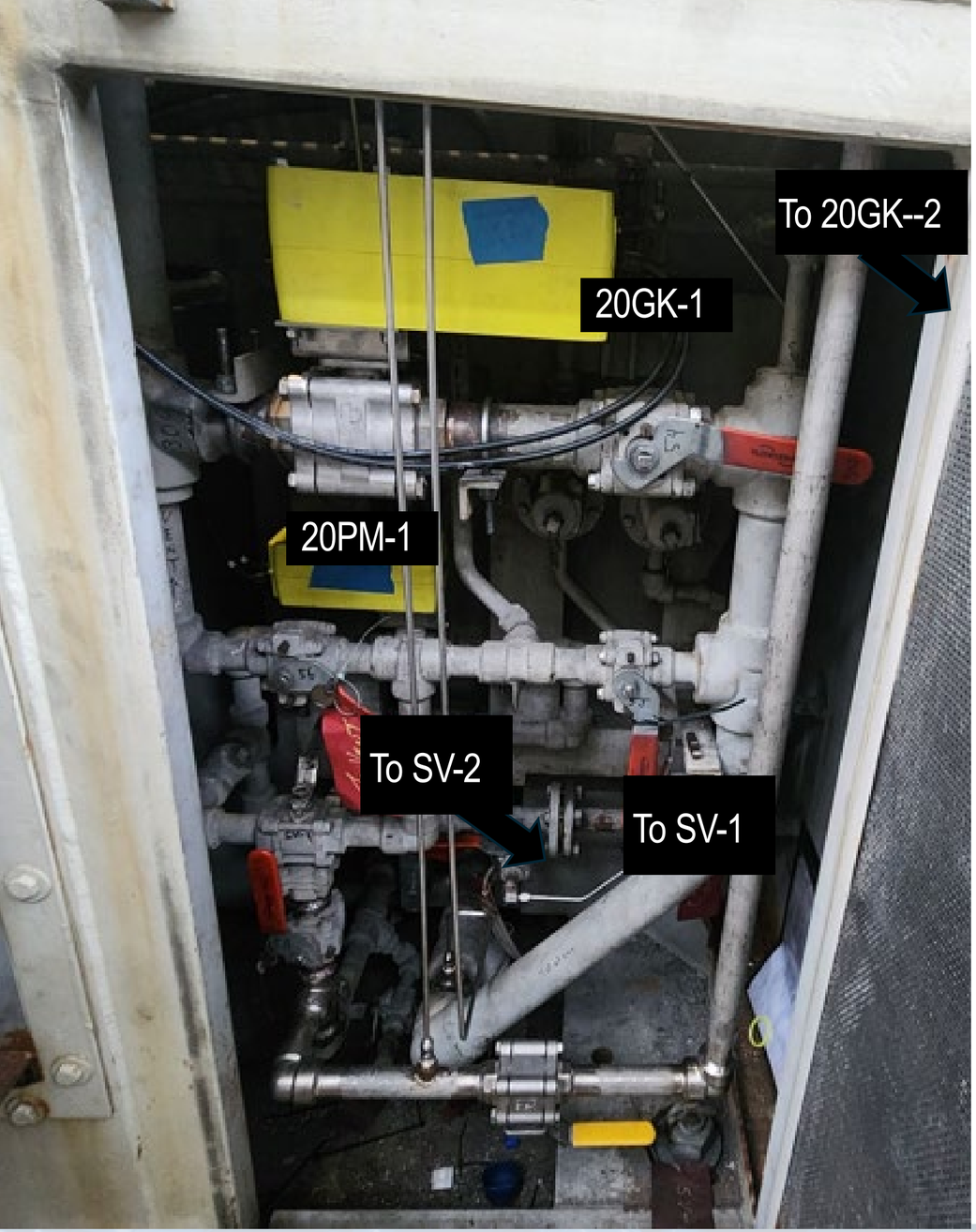
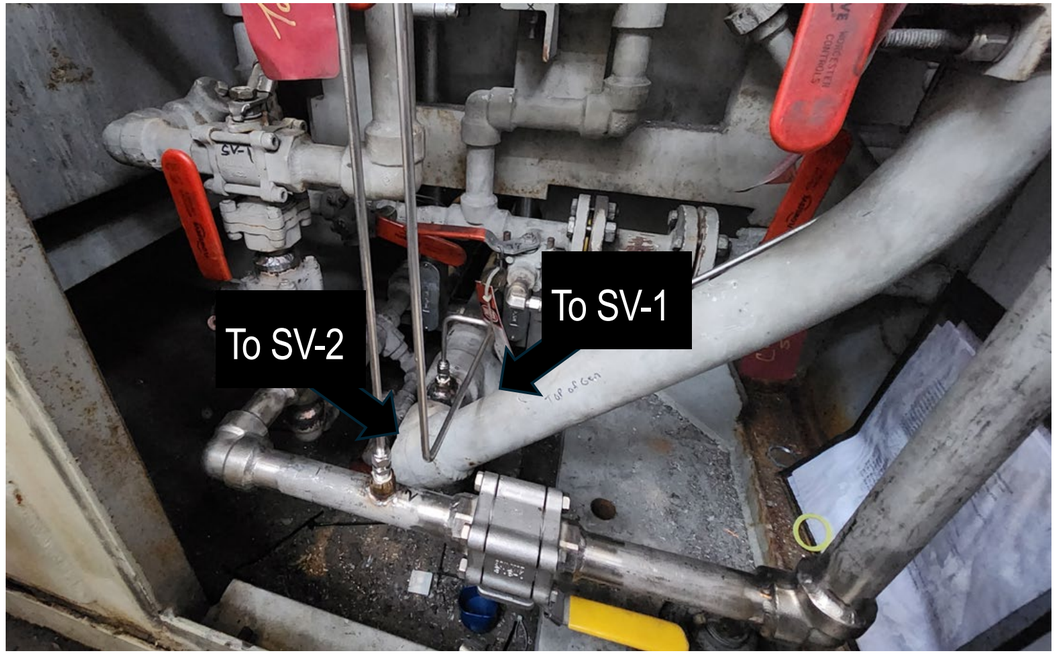
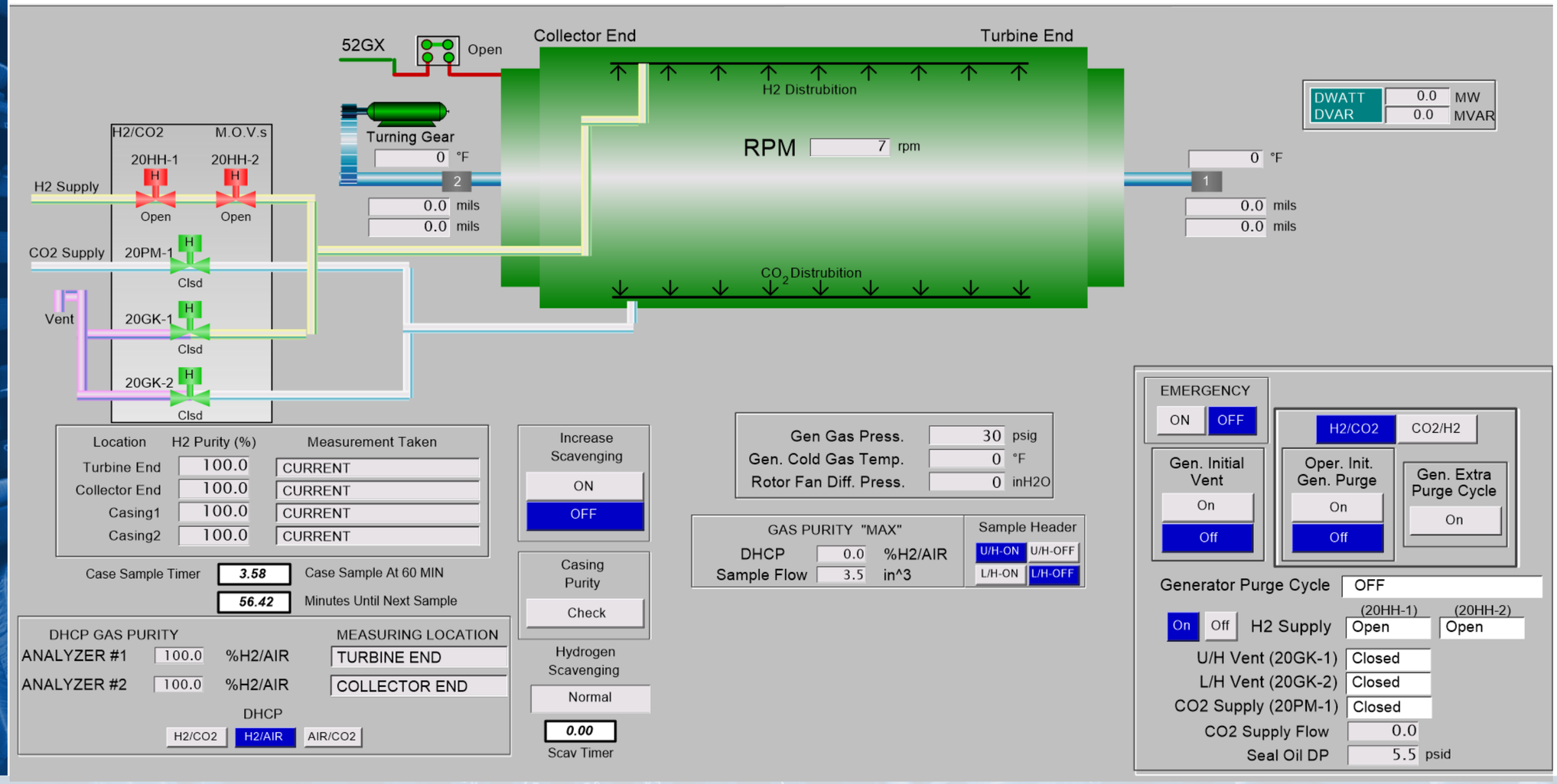
Operator-Initiated Purge: Enhancements





1. Modifications allow for DHCP direct sampling from the Generator Upper Header or Lower Header as directed by type of purge operation being conducted.
2. CO_2 Supply MOV (20PM-1) installed to control CO_2 admission
3. MOV (20GK-1) installed to control Generator venting from upper header.

Operator-Initiated Purge: Enhancements



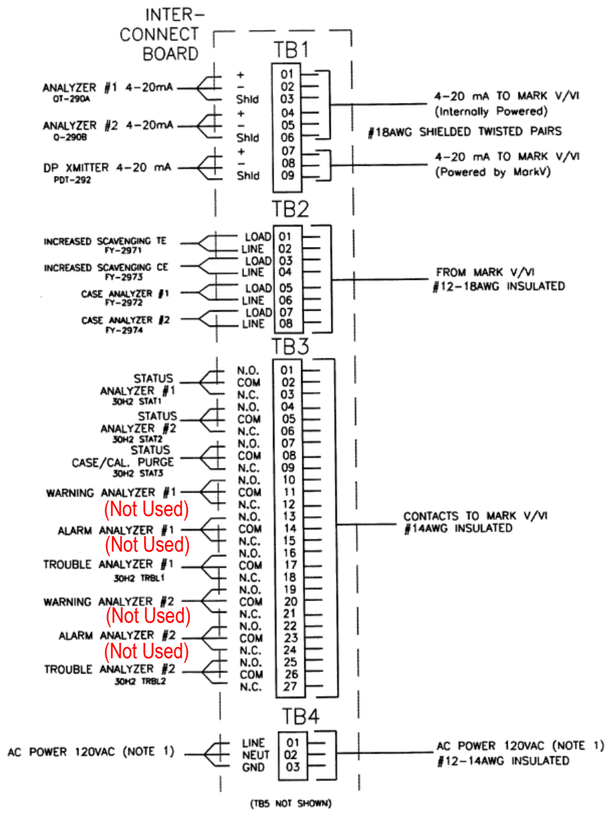
Operator-Initiated Purge: Features

- Remote-Generator **Emergency Purging** (H_2/CO_2)
- Remote-**Maintenance Purging** of the Generator (H_2/CO_2), (CO_2/H_2)
- Protects generator frame against oil intrusion during purging activities
- Mitigates freezing of CO_2 supply to generator
- Utilizes less CO_2 by volume than conventional manual purging methods
- Integrates existing equipment into control and monitoring of purging activities
- Remote monitoring of generator gas concentrations **(H_2/Air, H2/CO_2, Air/CO_2)**
- Enables vent gas continuous monitoring (purity, flow)
- Vent sample taken from appropriate generator header based on purge type
- Enables H_2 venting without CO_2 admission

Auto Purge: Background/History

DHCP Cabinets

(Original)



GEN2 and GEN3	
Contact Inputs (To MKV)	Description
L30H2STAT1	QD1-DTBA-023 Status Analyzer #1[30H2STAT1]
L30H2STAT2	QD1-DTBA-025 Status Analyzer #2 [30H2STAT2]
L30H2STAT3	QD1-DTBA-027 Sampling status, Case or CAL/PURGE [30H2STAT3]
L30H2TRBL1	QD2-DTBA-009 Hydrogen Analyzer #1 General Fault[30H2TRBL1]
L30H2TRBL2	QD2-DTBA-011 Hydrogen Analyzer #2 General Fault[30H2TRBL2]
Analog Inputs (To MKV)	
HYD_PUR1_SCA	R -TBQC-062 Cell #1 H2 Purity Signal [QT-290A]
HYD_PUR2_SCA	R -TBQC-065 Cell #2 H2 Purity Signal[QT-290B]
H2FDP	C -CTBA-058 Generator rotor fan differential pressure[PDT-292]
Contact Outputs (From MKV)	
L20CASE1	QD1-DTBC-073 CONTACT TO PORT ANALYZER 1 TO GEN CASE. [20CASE1]
L20CASE2	QD1-DTBC-076 CONTACT TO SAMPLE GEN CASE WITH ANALYZER 2 [20CASE2]
L20SCAV1	QD1-DTBC-082 CONTACT TO FY-2971 [20SCAV1]
L20SCAV2	QD1-DTBC-085 CONTACT TO FY-2973 [20SCAV2]

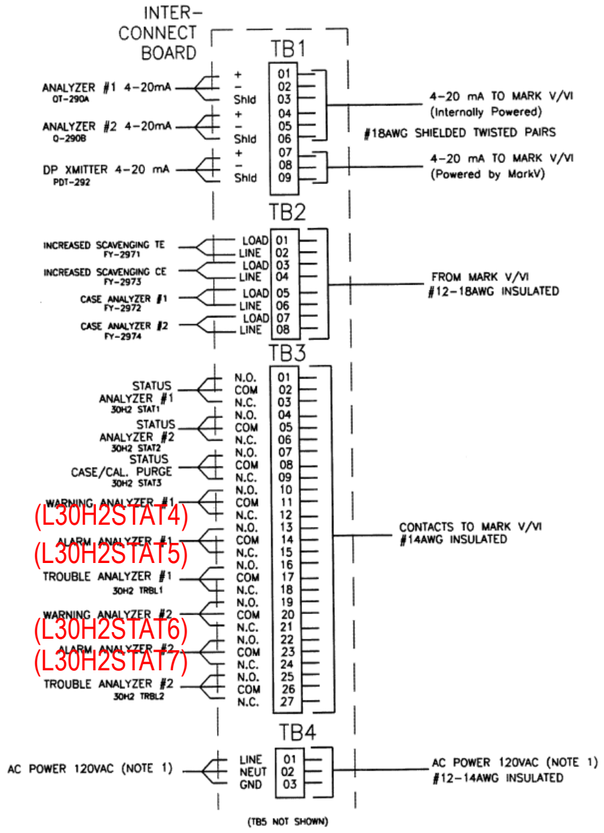
Operator-Initiated Generator Purge

- Operator chooses during any point of unit operation
- New vent/purge valves provide generator gas controllability within 1 psi
- Once selected, control system initiates shutdown
- Initiates purge once unit is detected to be at or below turning gear speed
- Allows operations to bleed pressure prior to purging if desired
- Alleviates oil intrusion concerns from loss of generator pressure
- Improved oversight surrounding the purge process
- Allows generator to be purged to CO_2 with minimal staff
- Automatic purging enabled should the control system sense loss of seal oil differential pressure

Auto Purge: Background/History

DHCP Cabinets

(Modified)



GEN2 and GEN3		
Contact Inputs (To MKV)	Description	
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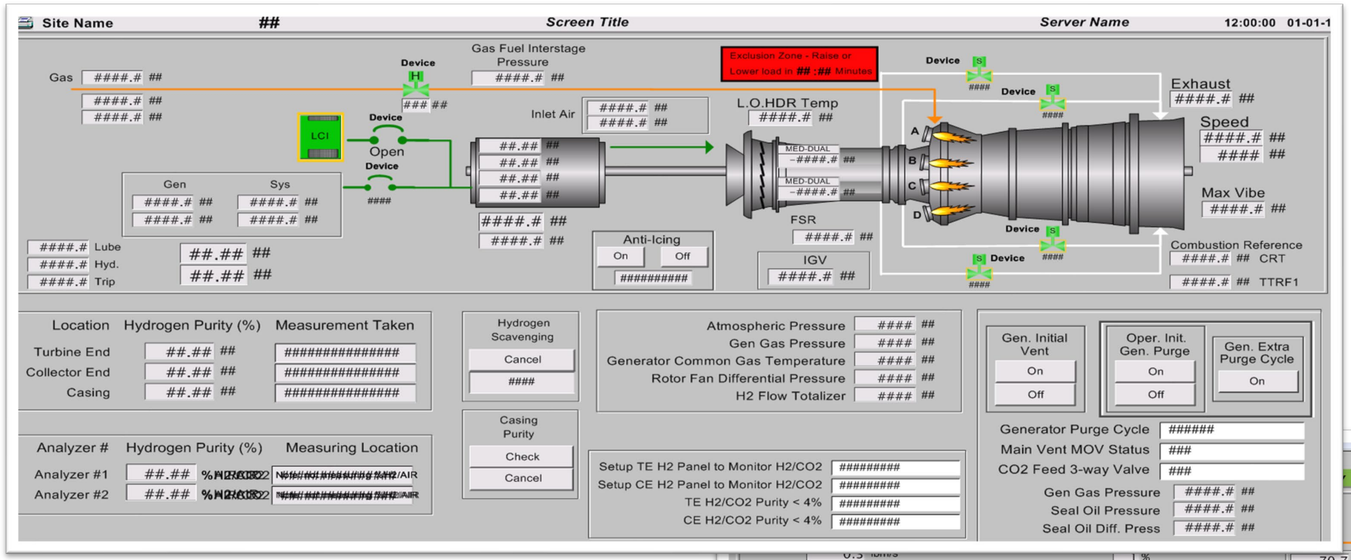
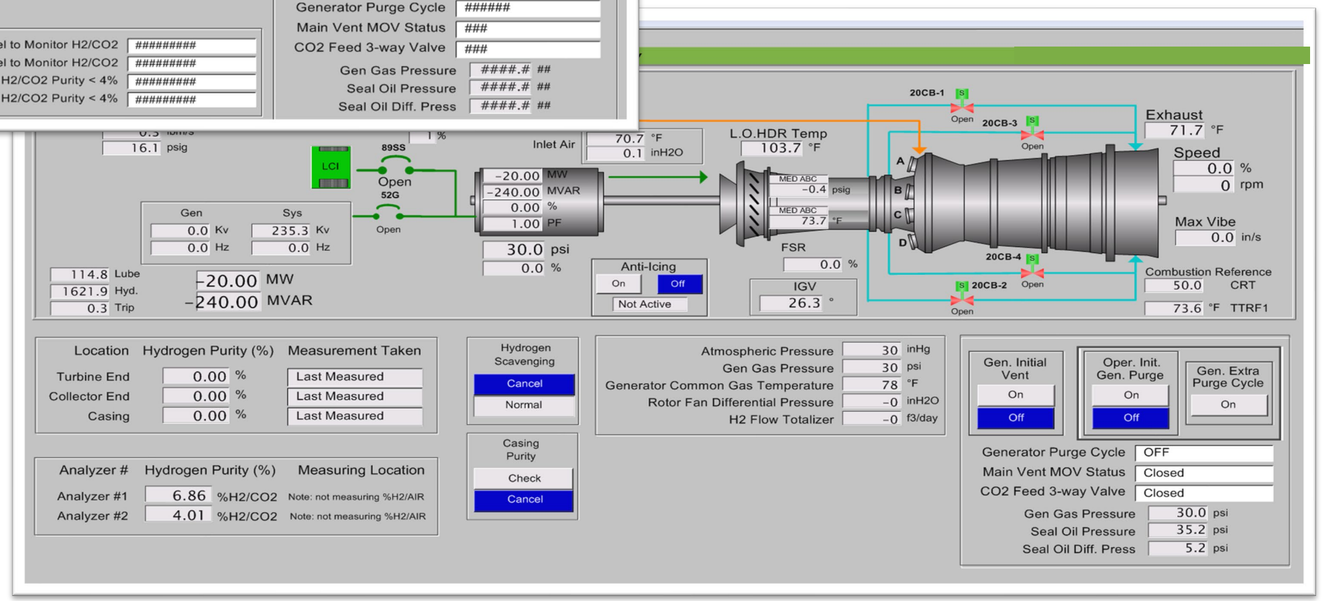
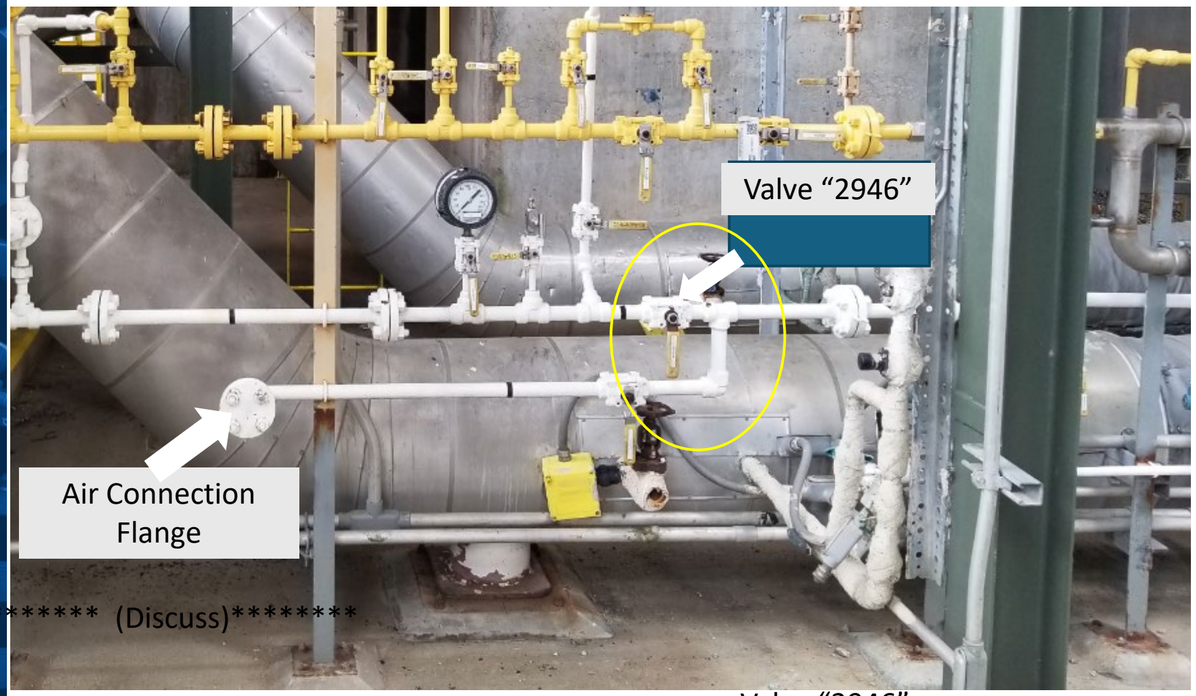
L30H2STAT2	QD1-DTBA-025 Status Analyzer #2 [30H2STAT2]	
L30H2STAT3	QD1-DTBA-027 Sampling status, Case or CAL/PURGE [30H2STAT3]	
L30H2TRBL1	QD2-DTBA-009 Hydrogen Analyzer #1 General Fault[30H2TRBL1]	
L30H2TRBL2	QD2-DTBA-011 Hydrogen Analyzer #2 General Fault[30H2TRBL2]	
Analog Inputs (To MKV)		
HYD_PUR1_SCA	R -TBQC-062 Cell #1 H2 Purity Signal [QT-290A]	
HYD_PUR2_SCA	R -TBQC-065 Cell #2 H2 Purity Signal[QT-290B]	
H2FDP	C -CTBA-058 Generator rotor fan differential pressure[PDT-292]	
Contact Outputs (From MKV)		
L20CASE1	QD1-DTBC-073 CONTACT TO PORT ANALYZER 1 TO GEN CASE. [20CASE1]	
L20CASE2	QD1-DTBC-076 CONTACT TO SAMPLE GEN CASE WITH ANALYZER 2 [20CASE2]	
L20SCAV1	QD1-DTBC-082 CONTACT TO FY-2971 [20SCAV1]	
L20SCAV2	QD1-DTBC-085 CONTACT TO FY-2973 [20SCAV2]	
Proposed Contacts		
Contact Inputs (To MKV)		
L30H2STAT4	CD-DTBB-17 Analyzer #1 Status H2/CO2 Selected	Reassigned from Warning Analyzer #1
L30H2STAT5	CD-DTBB-19 Analyzer #1 Status Air/CO2 Selected	Reassigned from Alarm Analyzer #1
L30H2STAT6	CD-DTBB-21 Analyzer #2 Status H2/CO2 Selected	Reassigned from Warning Analyzer #2
L30H2STAT7	CD-DTBB-23 Analyzer #2 Status Air/CO2 Selected	Reassigned from Alarm Analyzer #2

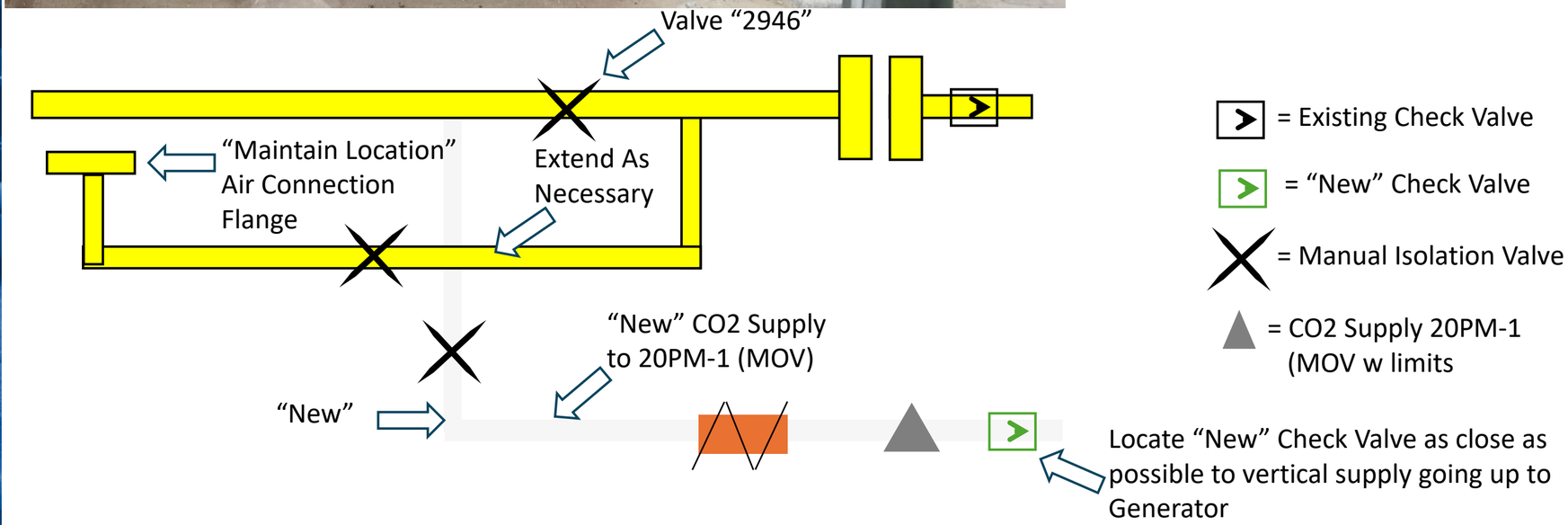
Operator-Initiated Generator Purge





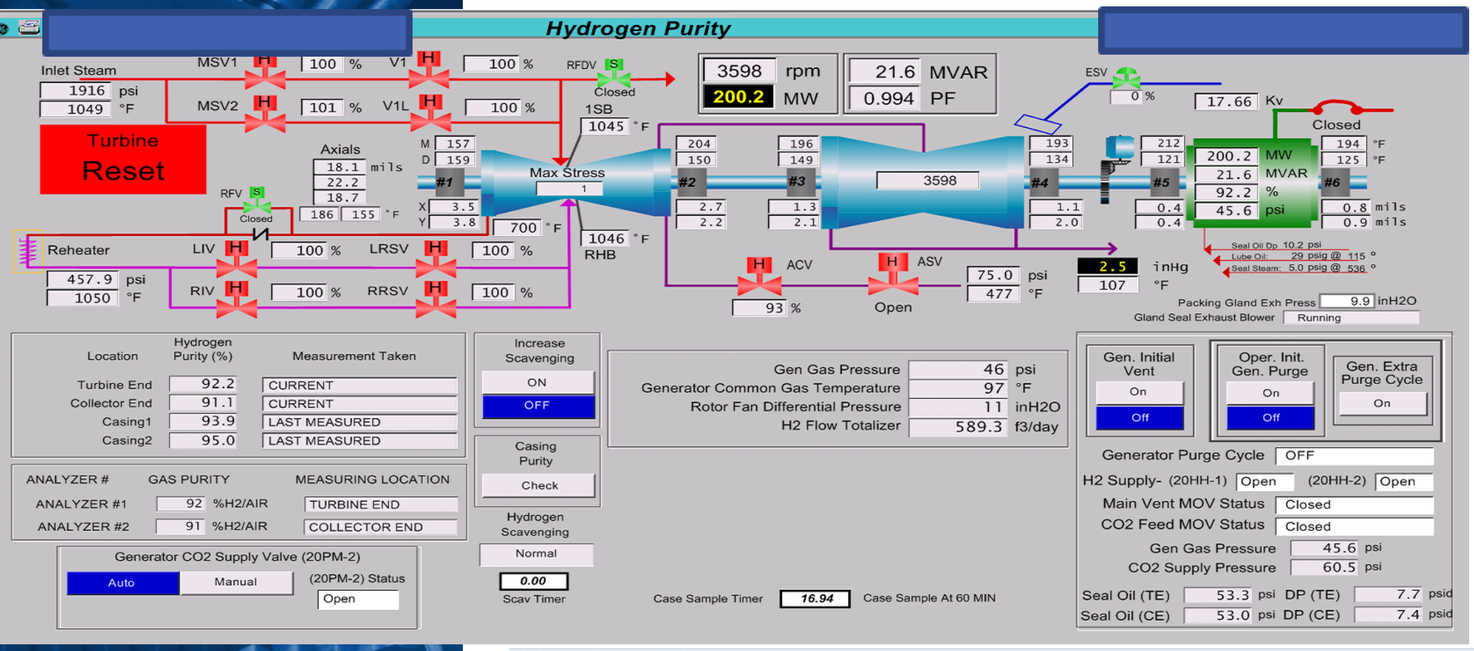
Operator-Initiated Generator Purge

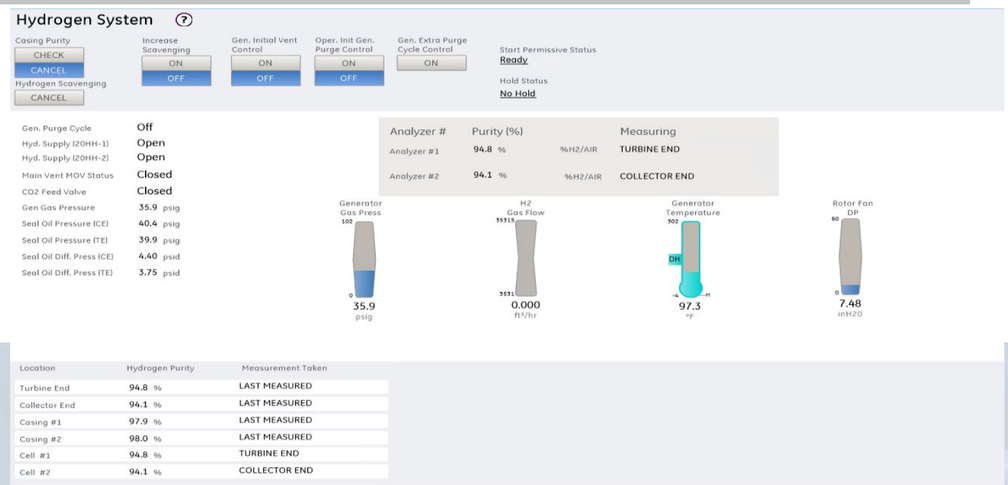




Operator-Initiated Generator Purge

Contemplating a Similar Project at Your Facility?





- Be mindful of seal oil monitoring control
- CO_2 use: waste
- Adequate isolation of H_2 supply
- Monitoring/controlling purge process
- Automatic purging (When?)
- Scrutinize existing connections/process during installation


Thank You
It’s all about SAFETY, RISK MITIGATION, and RELIABILTY