

CHEMETRON
Fire Systems™

CARDOX

CO₂

**Application
Bulletin**

CHEMETRON
Fire Systems™
A World of Protection



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CARBON DIOXIDE FIRE SUPPRESSION —

Hydrogen Cooled Electric Generators Inerting/Purging Systems

When the generator rotor is turned at high speed in larger steam turbine units, the turbine must overcome the resistance to the turning rotor created by the atmosphere in the generator casing. This wasted energy use is called *windage loss*. To reduce this *windage loss* to a minimum, the air in the casing is replaced with hydrogen, our lightest gas.

When the unit is first installed, the casing is full of air. The air cannot be directly replaced with hydrogen without going through the explosive range (which is quite broad for hydrogen). Similarly, when taking a unit from service, the hydrogen in the unit cannot be directly bled off and replaced with air without again going through the explosive range. To keep from creating an explosive atmosphere, CO₂ is used to inert the air before the hydrogen is introduced into the casing. Then the CO₂/air mixture is replaced by the hydrogen. To empty the casing, the hydrogen is purged by CO₂ and then the unit ventilated when the casing is opened.

The generator manufacturer builds a CO₂ manifold into the bottom of the machine (CO₂ being heavy) and a hydrogen manifold in the top (hydrogen being light). This helps prevent mixing and reduces the amount of gas needed. This gas exchange is normally done on turning gear. More gas is needed if done at speed. (See the diagram on page 4 which illustrates this inerting/ purging operation.)

Purging the hydrogen from the machine is usually estimated to require about two volumes of CO₂. To replace the air before hydrogen is introduced will take 1½ volumes. Thus, it can be estimated that it will take 3½ volumes of CO₂ to take a unit out of service, open the casing, and then return the unit to service. If done at speed, it could take 5 volumes.

Years ago, it was common practice for the generator manufacturer to provide a CO₂ supply of high pressure cylinders manifolded together. These were not fire system cylinders, but rather cylinders with manual valves at the cylinder vapor spaces. With this arrangement, CO₂ vapor is bled off from the cylinders into a manifold, and then regulated pressure CO₂ introduced into the generator through the controls and manifold provided by the machine manufacturer.

Liquid CO₂ is **not** used; vapor is withdrawn, which prevents the cooling that occurs when liquid is discharged. As the vapor from the cylinder is bled off, the pressure in the cylinder drops and the flow slows. In the time usually allotted for purging, all the CO₂ in the cylinders cannot be recovered unless external heating is used. It can be assumed that perhaps 70% is recoverable. (If it's hot and you allow enough time, this percentage will increase.)

The disadvantages of the cylinder system are:

- 1** There is only a minimum amount of CO₂ available. Thus, if a second purge is needed, there could be delays until a replacement CO₂ supply is obtained.
- 2** The CO₂ flow rate is determined by the vapor bleed off rate, which is a function of how many cylinders are bleeding and the heat input to the cylinders. It is hard to increase the rate if this should ever prove necessary. In an emergency, it may be appropriate to purge the hydrogen as fast as possible.
- 3** Plant personnel have to handle high pressure gas cylinders, which is always a risk. For this reason, the industry trend is to bulk gas systems. Special rigs for handling cylinders to prevent an accident — where the cylinder becomes a projectile — are common.
- 4** Cylinder CO₂ is more costly and not as readily available as bulk liquid CO₂.

Except for very small generating units, CO₂ in cylinders is rarely used today. Rather, the bulk low

pressure system is favored. With the low pressure CO₂ system, the CO₂ vapor needed is obtained by taking liquid CO₂ from the unit and putting it through a *direct to process* vaporizer. This adds the heat of vaporization (about 120 BTUs/lb.), plus the additional heat required to get the CO₂ temperature up to the desired level. The CO₂ vapor then goes through a flow control manifold (throttling valve, regulator with gauge) to establish the proper flow rate. CO₂ is usually used at 75 - 90 psi with a purge time of an hour or two. The flow control schemes are normally redundant. When the flow rate is established, it is normally left set at that level, but can be easily increased in an emergency. If a system with remotely actuated operating valves is required, this is easily accomplished. Refer to the drawing of the Carbon Dioxide Purging System, which illustrates an arrangement where the CO₂ main control valve is electrically operated, which allows pushbutton operation. The electric vaporizer is a demand type with thermostatic control; when the valve opens and cold CO₂ liquid is introduced into the vaporizer, the platen heating elements are automatically turned on. Therefore, the unit is always ready to go, but uses no power until heating is needed.

Since the maximum flow rate is a function of the capacity of the vaporizer, the vaporizer is sized to a worst case condition. Increases in vaporizer capacity do not proportionately increase the cost.

The advantages of the low pressure system and the ability to use this same storage unit for multiple purposes (hydrogen purging, coal silo inerting, fixed fire protection, hand hose line coverage, etc.) has made it virtually an industry standard.

More details on specific system arrangement are available from **Chemetron**.

Other Inerting Uses

When there is any application for CO₂ vapor, the setup for using the LPCO₂ System and the *direct to process* vaporizer to give the required quantities of vapor are virtually the same as that described above

for the hydrogen purge. Each pound of CO₂ will expand to about 8.3 cubic feet of vapor at atmospheric conditions. The volume of CO₂ required is calculated and converted to pounds as this is how the vaporizers are rated.

Basic units are:	375 lb./hour	15 KW
	750 lb./hour	38 KW
	1,125 lb./hour	45 KW
	1,500 lb./hour	60 KW

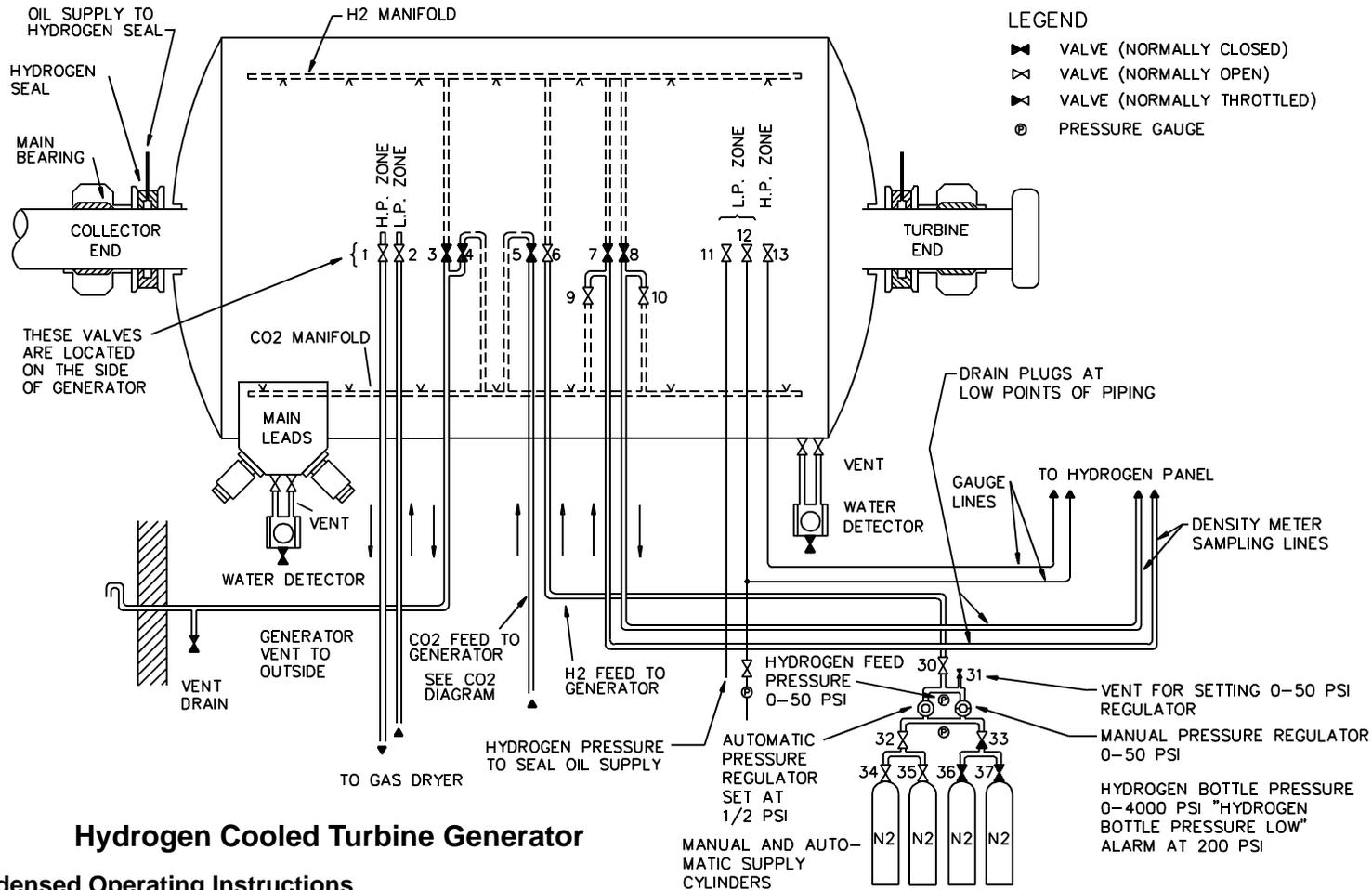
These *direct to process* vaporizers provide standard features, including a weatherproof enclosure, replaceable pressure cast heater platens, low discharge temperature safety shutoff, and circuit breaker load projection.

If only intermittent use of CO₂ vapor is contemplated, one vaporizer can usually satisfy two uses.



REGULATORY ALERT

WHERE CO₂ IS USED, COPIES OF THE MATERIAL SAFETY DATA SHEETS (MSDS) SHOULD BE OBTAINED FROM THE CO₂ GAS SUPPLIER TO PROVIDE ALL WHO USE THIS PRODUCT WITH A COPY PER OSHA HAZARD COMMUNICATION STANDARD 29 CFR 1910.1200(G).



Hydrogen Cooled Turbine Generator

Condensed Operating Instructions

General - The gas changing operations may be performed with the generator at standstill, on the turning gear, or at speed with load limited to 50%. Shaft seal oil pressure must be maintained.

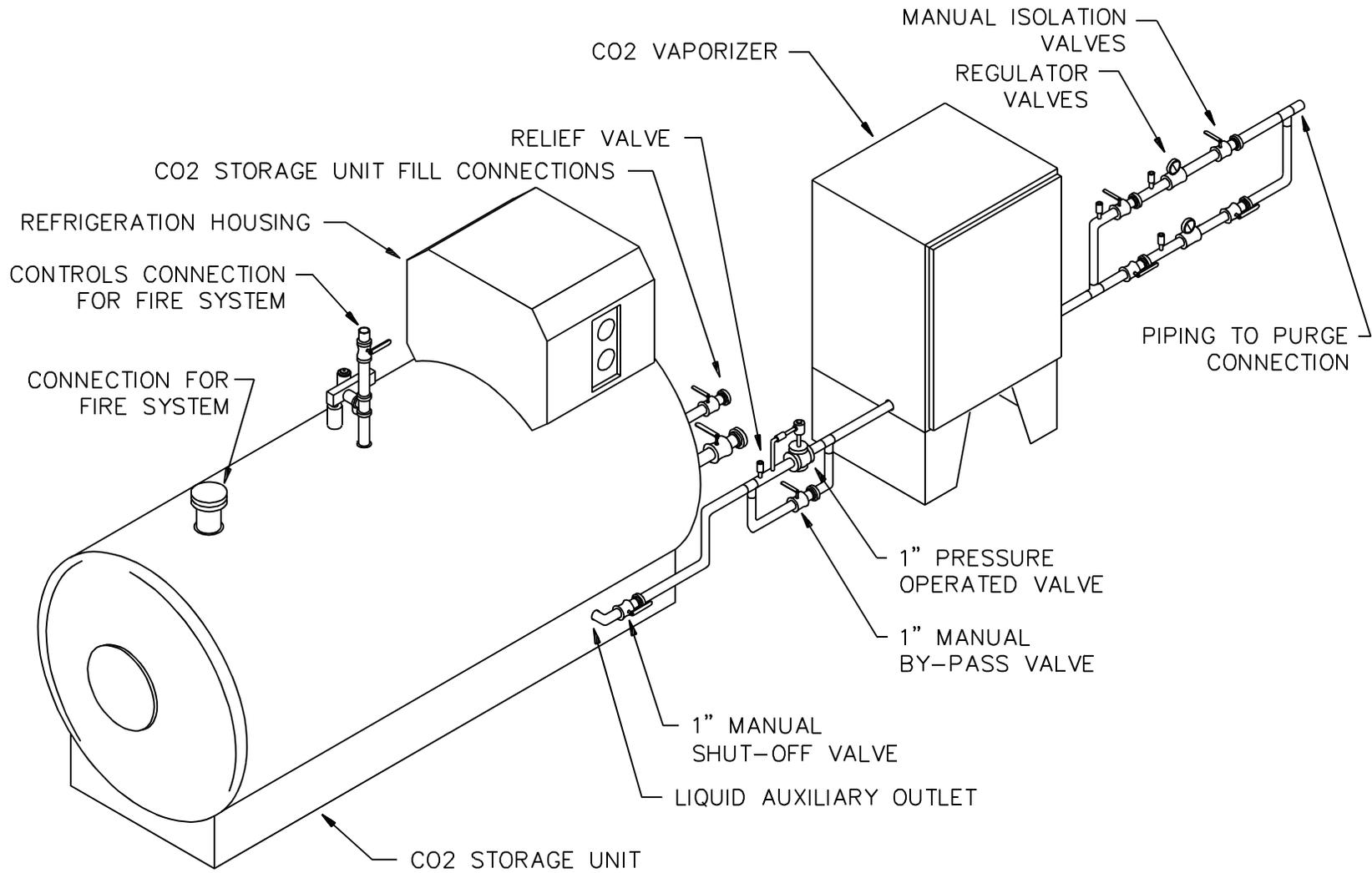
Replacing Air With CO₂ - The normal setting of the valves is indicated on the diagram. Open 7 and 8, close 9 and 10, open 3 and 5. Then admit CO₂. 1-1/2 volumes of CO₂ are required at standstill or on turning gear; 2 volumes of CO₂ are required at speed. When finished, change valves back to normal: close 3 and 5, open 9 and 10, close 7 and 8.

Replacing CO₂ With H₂ - Open 3; open 50 psi regulator. Open 34 and 35; open 32. Bottle pressure should be approximately 2,000 psi. When the bottle pressure drops to 200 psi, close 32 and open 36, 37, and 33, and continue. 2-1/2 volumes of H₂ are required at standstill or on turning gear; 3-1/2 volumes of H₂ are required

at speed; standard H₂ bottles contain 190 cu.ft. When finished, close 50 psi regulator and 3; 1/2 psi regulator will maintain pressure. Operation is then normal as indicated on diagram.

Normal H₂ Operation - 1/2 psi regulator will maintain pressure. The 0 to 50 psi regulator may be used to hold pressure between 1 and 15 psi. When changing bottles, check for leaks by closing the bottle valves and checking the bottle pressure gauge, which should not drop appreciably in 5 minutes.

Replacing H₂ With CO₂ - This operation is the same as replacing air with CO₂, except that 2 volumes of CO₂ are required at standstill or on turning gear, and 3 volumes of CO₂ are required at speed.



**Low Pressure CO₂ Purging System
for Hydrogen Cooled Electric Generator**