CHEMETRON™
Fire Systems

CARDOX

CO_2

Application
Bulletin

CARBON DIOXIDE FIRE SUPPRESSION —

Oil Insulated Transformers

Proper fire protection for oil insulated transformers is essential to minimize damage to the transformer and associated structure, as well as any exposed facilities. This includes physical separation[(1)] and, for critical units, a fixed fire control system. The traditional fixed fire protection for transformers not in vaults has been coverage of the transformer shell and bushings with a water deluge system designed to the specific requirements of the hazard. [Example: 0.25 g.p.m. per sq.ft. - 10.02 L/min/m^2 - over entire tank area for a total of 60 minutes.][(2)]

However, water has not always been the agent of choice for this protection and a significant number of transformers have been protected by CARDOX® low pressure carbon dioxide systems. These systems have proven to be cost-effective where there is an inadequate fire protection water supply or where the runoff from the deluge system discharge might cause environmental problems, necessitating creation of water retention structures and a plan to deal with the oil contaminated water as a "hazardous material." This bulletin is written to provide the background of the development of this protection and an insight into the basis of design of a proper low pressure CO_2 system.

NOTE

THE PROTECTION OF TRANSFORMERS IN VAULTS OR STRUCTURES WITH ADEQUATE FIRE RESISTIVITY CAN BE PROVIDED BY CO_2 TOTAL FLOODING (SEE BULLETIN #0315 - ELECTRIC ARC FURNACE TRANSFORMER VAULTS) OR BY A FIXED WATER MIST TOTAL FLOODING SYSTEM (SEE BULLETIN #0780 - MACHINERY SPACES). THE USE OF HALOCARBON AGENTS IN THE PROTECTION OF TRANSFORMER VAULTS IS NOT RECOMMENDED, ESPECIALLY WHERE THERE IS SWITCHGEAR INVOLVED.

In the early days of Cardox development of the technology for the use and application of low pressure CO_2, several significant test programs were used to define the suitability and design methods for outdoor transformer protection.

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A World of Protection

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Issued 2/2002

Branded: 06/2023 20230601SM

A relatively large transformer, equipped with an external oil heater, was obtained and installed in a pit at the Cardox facility in Monee, Illinois. An aircraft engine with propeller on a stand was also provided. The transformer shell was arranged such that transformer oil could be pumped from the heater into the shell and out a fissure in the top of the shell, with an overflow into the pit. In the fire tests, the oil was first heated to simulate the condition in the transformer when it experiences an internal fault that heats the oil and "pops" the shell, so that the oil will flow down the side of the transformer.

A series of fire tests were run. The hot oil was ignited, involving oil pumped from the transformer and the pit, and allowed to preburn so that everything was very not. Then the CO_2 system was discharged.

An array of nozzles was provided, surrounding the transformer. Cardox "CN" nozzles were used in what was known in those days as "direct application" (now "local application"). The CN nozzle is a heavy, solid brass nozzle with pipe connections of 1" (25.4 mm) to 1-1/2" (38 mm). It is rugged enough to survive virtually any fire. The CO_2 flow rate of this nozzle ranges up to around 750 lbs (341 kgs) per minute for the 1-1/2" nozzle. For this application, the 1" CN with a flow rate of up to 300 lbs (136.3 kgs) per minute was (and still is) used. The system flow rate is the total of the nozzle flow rates. The number of nozzles is determined by the size of the transformer and the available nozzle mounting locations. (See the discussion on nozzle placement later in this bulletin.)

The projection capability of the CN nozzle is significant, even though it has a wider angle discharge pattern than most CO_2 local application nozzles. It has a UL local application projection approval to 18 feet (15.9 m). As shown in the accompanying photos, its discharge forms a "beautiful" pattern that ensures that all surfaces are covered during the discharge.

In order to evaluate the effects of high winds, the "prop-wash" of the aircraft engine was directed at the transformer during some of these tests.

The basic discharge time was established at one (1) minute and no reflashes were experienced following successful extinguishments. This is double the discharge time normally used on local application CO_2 systems today.

Not too surprisingly, it was found that the high air blast actually helped extinguishment. In a similar effect as blowing on a match, the wind carried the fire away from the transformer, minimizing the heating of the metal surfaces and the potential for reignition after the discharge.

We were not very concerned as to whether or not the system could be designed to sufficiently project the $LPCO_2$ discharge (which is almost half solid particles of dry ice) into the wind. The Cardox $LPCO_2$ aircraft crash fire rescue trucks, built by the hundreds for the Armed Forces during WWII and the Korean War, successfully fought hundreds (perhaps thousands) of aircraft crash fires with low pressure CO_2 under all manner of weather conditions.

Some years later, "Automatic" Sprinkler Corp., at their Youngstown, Ohio facility, installed a large transformer with three types of fire suppression - a "small nozzle" water system, a "large nozzle" water system, and a Cardox $LPCO_2$ system. They invited many prospective customers to witness actual fires and their extinguishment. All systems repeatedly did the job.

A significant number of actual installations have been made - usually where there are problems with providing an adequate water supply, making the Cardox system cost competitive.

There are a number of factors in the facility design and arrangement that need to be discussed here.

The hazard must be contained. In an actual incident involving a water protected transformer, the flaming oil spewed out in such a way that it ran down an adjacent road, spreading the fire way beyond the protected hazard. A question was raised as to whether a CO_2 discharge cloud, which spreads out over the ground, might have controlled the spread of this fire. This is not likely. The system is expected to be effective only where the CO_2 is actually discharged - the immediate area of the transformer. A crushed rock pit or similar containment is usually provided to keep the fire within the protected area. Whether this or a diked area is provided, containing the burning oil within the protection is very important.

Separating walls, while providing separation between units, can also be of value in the design of a CO_2 system. The discharge can be banked into the transformer alcove from nozzles across the front of the unit, containing more of the CO_2 for a longer time.

Electrical Clearances: It is obviously important that proper electrical clearances be maintained. See NFPA Standard No. 12, Paragraph 1-6.2 and Table 1-6.2.

Nozzle Placement: A combination of proper nozzle locations that incorporate the required CO_2 flow rates, their associated projection distances and patterns, together with maintaining proper electrical clearances of piping and nozzles, requires a skilled system designer.

The photographs accompanying this bulletin were taken to show the full discharge sequence when this particular installation was tested to verify the coverage. They give a better description of the Cardox protection discharge than can adequately be described here.

Safety: Consideration must be given to where the CO_2 will flow during and after a discharge to ensure that the resulting "cloud" will not create a personnel hazard. Normally this is not a problem outdoors, but this condition needs evaluation on every installation and verification by the final discharge test. Personnel warning measures must be complete and fully effective.

Chemetron's Systems Application Engineering group is available to consult on any specific application evaluation.

(1) NFPA Standard #850, Recommended Practice for Fire Protection for Electrical Generating Plants and High Voltage Converter Stations

(2) FMRC Loss Prevention Data Sheet #5-4