Cardox 101

1.0. Introduction

The Cardox system was first invented in 1925 in the United Kingdom. Commercial operations began in 1930, and the company have expanded their reach in the UK to become the premier non-explosive' s material breaking solution. As well as having majority market share nationally for non-explosives (required) projects, they have expanded their reach globally. After over 90 years since the company opened, they now have a presence in over 45 countries.

We at Cardox (Lanka) Pvt Ltd are the official and sole agents for the Cardox system in Sri Lanka. Our team has received training and are certified by Cardox UK for the application of the Cardox system for civil works.

The Cardox system is a non-explosives rock breaking method created to be an alternative to explosives and chemical blasting. Its application produces negligible levels of ground vibrations, no fly rock, very little sound and no release of hazardous chemicals. The tube assemblies of Cardox system are completely waterproof, further expanding their breadth of application.

The Cardox system is truly versatile – It has been used for general rock excavation, quarrying, mining, tunneling, shaft sinking, trenching, and even underwater rock excavation.

2.0. What is the Cardox System?

The Cardox system is a non-explosives material breaking solution with 3 main sets of components.

The first set of sub-components are the tube assemblies: these are reusable steel tubes made from a proprietary alloy certified by Rolls Royce in the UK. The tube assemblies come in quite a number of different sizes and configurations for different applications. For civil applications on hard rock, the recommended Cardox tube assemblies are the F-57, and F-57L. While the F-57L tube assembly is larger, we chose the F-57 tube assembly because it can reach a higher discharge pressure.

Figure 1: F-Type Tube Body

Figure 2: F-Type Firing Head

Figure 3: F-Type Snub-nose Discharge Head

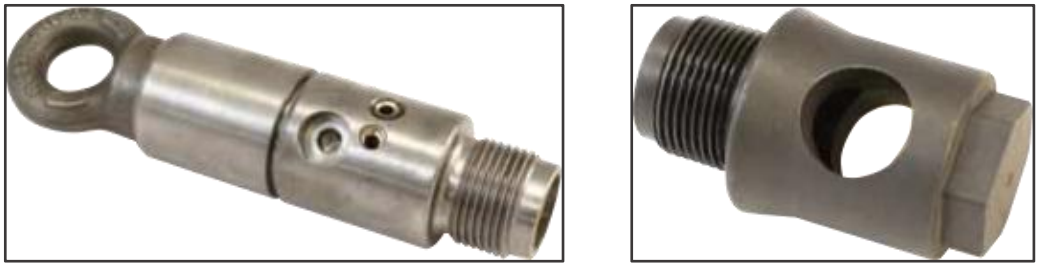


Figure 4: F-Type Multi-Holes Discharge Head (0.5m)

There are 2 types of discharge heads to choose from – the snub nose and multi-hole discharge heads. The merit of the snub nose discharge head is that it can produce a higher yield. Since there are only 2 points of discharge, the discharge pressure is highest. As such, the parameters of spacing and burden can be expanded. The multi-hole discharge has the advantage of better fragmentation due to the multiple discharge points. We plan to use both types of discharge heads as and when suitable.

The Cardox tubes are well known for their longevity. In most areas they' re a quarter inch thick steel alloy, and they have a lifespan of 2,000 Cardox activations.

The second set of Cardox components are the consumable sets.

Figure 5: Safety Heater

Figure 6: Rupture Disc

Figure 7: Copper Washer

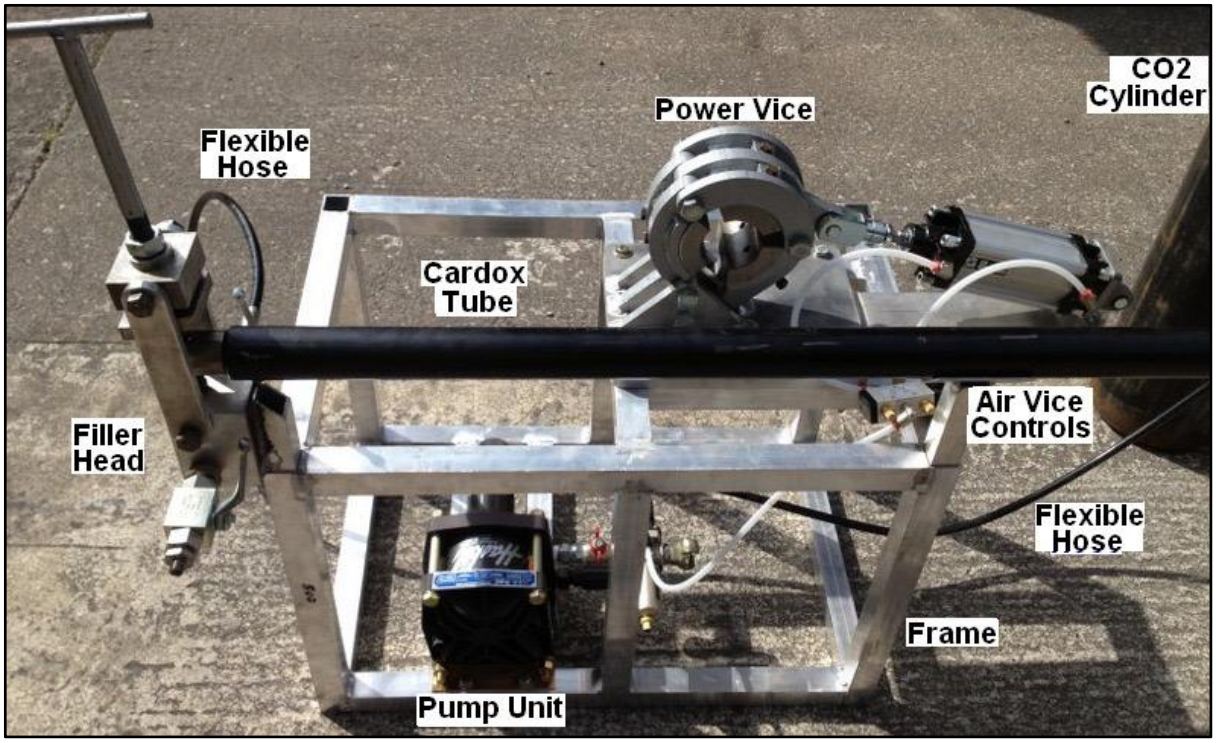
The components labeled above are the chosen consumables for the tube assembly. They are chosen based on tube compatibility and producing maximum yield.

The first component is the safety heater: it is made up from a patented composite of chemicals that reacts only in specific conditions. With 25 atmospheres of pressure and an electric charge to the copper wire on top, this component rapidly rises in temperature to begin the Cardox chemical reaction that will be explained further below.

The second and third components are the copper washer and rupture disc. The former part' s only task is to support the latter component, and the rupture disc' s task is to burst once sufficient pressure is achieved inside the tube.

The final component set is the recharging station. This machine is used to fill ('charge') the tube assemblies with liquid carbon-dioxide (CO_2). Liquid carbon-dioxide is an inert compound, and is the main 'charge' used for a Cardox activation. The reaction from the vaporization of the liquid CO_2 and subsequent rapid rise in pressure is necessary for rock to be broken. Again, a detailed explanation of the Cardox activation will be given below.

Figure 8: Recharging Station (labeled)



Once the consumables are inserted into the tubes, the power vice and spanner (in the recharging station) will be used to securely fasten both the firing and discharge heads to the body of the Cardox tube. Then, the firing head of the tube is then placed above the filler head and filled with liquid CO2.

3.0. How does the Cardox System Work?

The Cardox system is elegantly designed to be user friendly and functionally effective.

3.1. Preparation

Each end of the tube body has different thread types to match either the firing or discharge head: meaning there can be no mix-up between the top and bottom of the tube body. Beyond this, there are shoulders a few inches inside the tube body to house the relevant components. As preparation, all threads on the tube assembly are sprayed with WD40 for lubrication.

First, the heater is inserted into the top of the tube body where the firing head will be screwed on to. The heater has a copper band that allows it to rest on the shoulder in the tube body. The top of the heater has an exposed copper wire that would make contact with the electrode in the firing head that protrudes from the bottom of said head (successful contact will be tested later).

Once the firing head is screwed on to the top (post heater insertion), the tube will be overturned so that the other open end of the body faces the user. The copper washer will be placed on the shoulder of the tube body followed by the rupture disc, and the discharge will be screwed on top of them.

Once both heads are screwed on to the body by hand, the connected tube assembly is placed through the vice grip in the recharging station. Once the vice grip is engaged, a spanner is used to mechanically tighten both heads

securely to the body. The tube assembly is then placed laterally into the recharging station where a valve in the firing head fits into the filler head on the station. The head is secured in place and the tube is 'flushed' with liquid CO2. The process of 'flushing' involves filling the tube with small amount of liquid CO2 from a pump and cylinder attached to the recharging station, and releasing it quickly. This process cools the tube assembly: as a cooler tube can hold more CO2. The now cooled tube will properly be filled with liquid CO2.

Once filled, the tube is removed from the recharging station and leads from an ohmmeter will be inserted into the terminals in the firing head to check for electrical resistance. If the resistance falls within the acceptable range, the tubes are ready to be checked for leaks.

If the resistance is out of an acceptable range, the likely issue would be contact between the electrode and heater or less likely, an electrode malfunction. All potential issues can easily be addressed since we, as the official Cardox agents have the relevant training and spare parts to remedy them. Once the tube is filled, each head would be submerged into a bucket of water. Any potential bubbles would be observed: continuous bubbles after 7 – 10 seconds showing in the water is a sign of a leak. A potential leak would be addressed by tightening the heads, observing the valves and terminals, or even by disassembly of the tube. The 'charged' tubes can be safely stored for up to 3 days.

Figure 1: Ohmmeter Leads

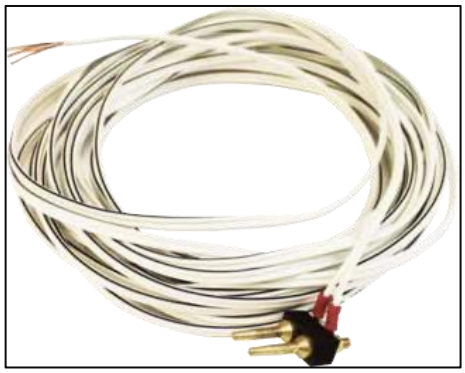


Figure 2: Ohmmeter

3.2. Loading, Activation & Recovery

Alongside the preparation of the tubes, the rock (or other mass) would be drilled into. The parameters of the project will be explained below. The drilling depth is 1.1m, despite the length of the tube being 1.2m: this is because the firing head needs to be exposed. Leads will be inserted (and temporarily sealed) into the terminals in the firing head of the tube. The length of the leads would be at the Cardox safety distance: 10 meters away from the activation zones. The opposite ends of the leads will be inserted in an activator.

The tubes would then be covered by a plate with a collar that sits on top the firing head. After the covering plate, a mat made of woven rubber will be placed on top – both these coverings absorb all blowback pressure produced from a Cardox activation.

Figure 3: Covering Plate

Figure 4: Covering Mat

Figure 3: MK815 Ignitor

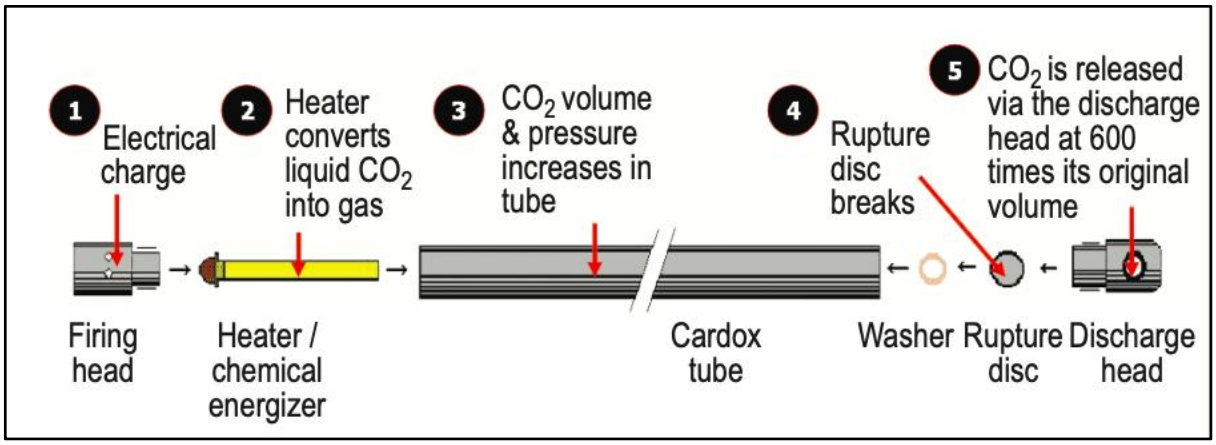
After the covering is complete, the tubes are activated. The process of activation is explained below:

Upon activation, an electrical impulse is sent from the activator to the firing head. This electrical impulse will 'initiate' the heater, and it will rapidly rise in temperature causing the liquid CO2 to vaporize (into a gas). CO2 in gaseous form occupies more space than the same in liquid form. So, this reaction swiftly increases the pressure in the tube causing the rupture disc behind the discharge head to burst. The CO2 gas rushes out

of the discharge head at 600 times its original volume, aerating, breaking and clearing the surrounding rock. The entire process explained in this paragraph take 1 second.

The tubes would be recovered, recharged and used again – further explanation on this matter is provided below.

Figure 4: Cardox Tube Activation Illustration



4.0. Benefits of the Cardox System

The Cardox system is firstly a non-explosives rock breaking solution. This statement is proven and verified from the multiple test certifications procured over the years from independent and recognized testing bodies. Just some of the testing certifications obtained proving the non-explosive classification of the Cardox system are from Dekra, Chilworth and HSE. Due to its non-explosive classification, importation, transportation, storage and use of the Cardox system is significantly easier compared to explosives.

Other advantage of the Cardox system is that it produces negligible levels of grounds vibrations, no fly rock, minimal noise, and no release of hazardous material.

The Velocity of Detonation (VOD) of an explosives blast could be up to 5,000 meters per second (m/s). With Cardox however, the VOD is 400m/s: less than 12 times the VOD of explosives. As such, the vibrations that would travel from a Cardox activation is a fraction of the vibrations produced from an explosives blast. Please observe some of the results of Cardox testing in the tables attached below:

Figure 5: Testing Conducted by Cardox UK

1) Vibration Level (mm/s)

	5mX	5mY	5mZ	10m	20m	No. OF TUBES ACTIVATED SIMULTANEOUSLY
Test 1 Single Tube	0.398	0.355	0.631	0.316	0.079	1
Test 2 Wedge Cut	0.282	0.251	0.631	0.447	0.200	2
Test 3a Bench Cut (1m)	2.82	1.59	3.55	0.631	0.100	3
Test 3b Bench Cut (1.5m)	1.59	0.282	2.512	0.447	0.100	2

Average Vibration Reading (mm/s)			
5m	10m	20m	30m
0.81	0.45	0.15	0.08

Image referenced from report by Cardox UK

Figure 6: Testing Conducted by Carnon Contracting

NO CARDOX TUBES	RESULTANT P.P.V. mm/sec	DISTANCE FACE TO SENSOR m	
4	0.54	9	
3	0.5	9	FAILED TO TRIGGER @ 0.5mm/s
5	0.54	8	
6	0.54	7	
5	0.39	8	
11	0.46	10	
11	0.46	9.5	
10	0.4	10	FAILED TO TRIGGER @ 0.4mm/s
6	0.4	10.5	FAILED TO TRIGGER @ 0.4mm/s
10	1.17	10	
10	0.97	10	
5	0.90	9.5	
9	1.87	9.5	

Image referenced from report by Carnon Contracting

The final 2 advantages of using the Cardox system are price and speed. The Cardox system fits in between explosives and chemical blasting. It is safer and just as effective as explosives blasting, and more affordable and faster compared to chemical blasting.