Study on Rock Caverns for Storage of Crude Oil

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Abstract: The crude oil storages are constructed in underground rock caverns. Rock caverns are large man-made spaces in the rock and are considered the safest means of storing hydrocarbons. Oil reserves are being built to provide the cushion during any external supply disruptions and to ensure India's energy security .the government of India decided maintains an emergency fuel store of total 5.33 MMT(million metric tons) of strategic crude oil storage at three locations at Visakhapatnam, Mangalore, and Padur (Andhra Pradesh, Karnataka, near udupi) the crude oil storage are constructed in underground rock caverns and are located on East and West coast of India. Crude oil from these caverns can be supplied to the indian refineries either through pipelines or through a combination of pipelines and coastal movement. the rock caverns storage purpose land investigation like the rock conditions type of rock required geology and geotechnical tests as considered. All the three locations Visakhapatnam (Vizag) (June 2015), Mangalore (October 2016) and padur (December 2018) have been commissioned.

KEYWORDS: Rock caverns, maintenance cost, steel tanks, hydrocarbons

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INTRODUCTION

The Gulf War in 1990 caused a sharp rise in oil prices and a massive increase to India's imports. During the subsequent 1991 Indian economic crisis, foreign exchange reserves could barely finance three weeks' worth of imports while the government came close to defaulting on its financial obligations. India was able to resolve the crisis through policies that liberalized the economy. However, India continued to be impacted by the volatility of oil prices. In 1998, the Atal Bihari Vajpayee administration proposed building petroleum reserves as a long-term solution to managing the oil market.2005 ISRL (Indian strategic reserves limited) the special purpose vehicle was established. Three storage facilities were built in underground locations in Mangalore, Visakhapatnam urm and Padur. A total of 5.33 MMT (million metric tons) storage capacities. The approved revised cost estimate for Visakhapatnam, Mangalore and padur are Rs.1178.35, Rs.1227 corers and Rs 1693 crores.

II. UNDERGROUND ROCK CAVERNS STORAGE OIL PRODUCTION SYSTEM

The principle of storage of oil in underground rock caverns essentially employs ground water pressure for containing the product within an unlined rock cavern. It is an established system successfully followed in many countries.

As oil has a lower density than water and is not soluble in it, all transmission of water which takes place through joints and fissures in the rock, proceeds towards the underground caverns and it is drained to a pump pit at the bottom of the storage cavern. The cavern bottom is designed with a drainage system, minimizing the contact between the product and the water. Since it is the water and not the rock that keeps the oil in, the rock cavern can in principle be of any shape provided that it is situated well below the ground water level.

Based on site investigations, horizontal caverns of sizes up to 20m in span and 25 to 32 m high are envisaged at Mangalore. The crown level of the caverns is proposed at (-) 30 m level below MSL. For the proposed storage, two 'U' shaped caverns are planned, parallel to each other, with leg lengths of 890 m each. The types of crude oils, viz High Sulphur and Low Sulphur are being stored in the ratio of 1:1 at Mangalore and 2:1 at Vishakhapatnam. The caverns are oriented in N 1000 E direction so as to come across minimum geological problems such as weak zones and shear zones while excavating the caverns. They have a D shaped cross section. For ensuring stability of the caverns, a support system of shotcreting and rock bolting is envisaged.

Two vertical shafts provide access to inlet oil pipe for the two types of crude oil and to the submersible pumps for pumping out the oil. Water seeping into the caverns is pumped out by submersible pumps to water treatment facilities located on the surface. A control system constantly monitors the oil and water levels in the caverns. For fire protection and for avoiding explosive atmosphere in the vapour space in the caverns, an inerting system is considered. From the ambient storage temperature, the crude oil will be heated to 40 degree centigrade through a heating and circulation system before dispatch. Provision is also kept to heat and circulate the crude at 70 degree centigrade for de-waxing and de-sludging, when small quantities of crude oil are left in the storage. A flare stack is provided for controlled release of vapour pressure inside the cavern, during full capacity intake of crude oil.

Water infiltration gallery and water curtains, 20 m above the crown level of the cavern, ensure a constant water pressure towards the caverns.

The submersible pumps in the caverns are designed to deliver the crude oil either to the nearest refineries or back loading in the tankers for dispatch to other refineries.

III. INDIA STRATEGIC PETROLEUM RESERVES (ISPR)

Strategic petroleum reserve : it is defined as crude oil inventories held by the government of a particular country as well as private industry, to safe guard the economy and the help maintain national security during an energy crisis.

ISPRL maintains an emergency fuel store of total 5.33 MMT (million metric tons) or 36.92 million barrels (5.870 million cubic meters) of strategic crude oil enough to provide 10 days of consumption Strategic crude oil storages are at three underground locations in Mangalore, Visakhapatnam and Padur (Udupi, Karnataka). All these are located on the east and west coasts of India which are readily accessible to the refineries. These strategic storages are in addition to the existing storages of crude oil and petroleum products with the oil companies and serve in response to external supply disruptions.

Indian refiners maintain 65 days of crude storage, so India has overall reserve oil storage of 87 days. an Indian company responsible for maintaining country's strategic petroleum reserves. ISPRL is a wholly owned subsidiary of the Oil Industry Development Board (OIDB), which functions under the administrative control of the Ministry of Petroleum.

ENERGY SECURITY: uninterrupted availability of energy sources at an affordable price. As per international energy agency storage of 90day of requirement storage capacity

Three locations is required Phase-I

- Viskapatnam,AP -1.33MMT
- Mangalore, Karnataka -1.5MMT
- Padur, Karnataka -2.5MMT

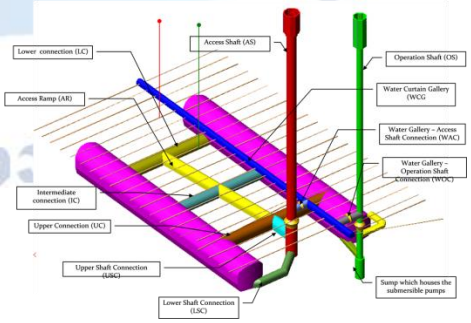
Visakhapatnam: in this site comprises of five caverns, three 840m long and tow 320m long each caverns width is 20m with a maximum height of 30m.the total tunneling facility is 7km.the constructed excavated by hard rock approximate 19 lakh cubic meters the bore hole drilling for water curtains is approximately 17km. The capacity of storage 1.03MMT (7.55MMbbl) in this project approved cost Rs.1178.35 crores and commencement of construction January, 2018 . This project total land area 67 acres two compartment capacity of MMT. First compartment 0.30(HPCL) second compartment 1.03 (ISPRL) the commissioned in 2015 June.

IV. PIPE LINES AND BOOSTER PUMP STATIONS

The strategic storage at the terminal will cater to the following refineries:

- OCL's Haldia and Barauni
- MRL, Chennai
- BRPL, Bongaigaon
- HPCL, Vizag

The existing unloading facilities for HPCL refinery for crude oil shall be used. The tap-off from existing pipeline shall be taken around 2 km from Jetty and location of strategic storage is around 2-3 km from the pipeline. The residual pressure at tap-off point is sufficient to transfer the crude oil to strategic storage. For transfer of crude oil out of strategic storage, transfer pumps shall be provided and the same pipeline shall be utilized to transfer crude oil to HPCL refinery and also to load ship tankers at HPCL Jetty for use in MRL, Haldia and other refineries. For IOCL's refineries at Haldia and Barauni and BRPL refinery at Bongaigaon, the crude transfer shall be from Haldia Jetty by existing onshore pipeline. Existing unloading facilities at HPCL Jetty shall be used for loading purpose also. The length of new 36" NB pipeline will be about 3 km.



MANGALORE: The Mangalore project is located over an area of 104.73 Acres the total approved cost Rs.1227 crores the storage capacity 1.5MMT (11MMbbl) it is constructed four parallel caverns tow of them area 913m long and two 873 m long the cavern width is 20 m with a maximum height of 31 m. the total tunneling including shafts of Mangalore facility exceeds 9.2km. It

is tow compartments required each compartment commencement of construction April, 2009.

PADUR: The Padur project is being constructed on 179.21 acres. the largest cavern crude reserve of these three strategic reserves in this country comprise 8parallel carvens,six of them 700m long and two are 656m long the cavern width is 20 m with a maximum hight of 31.40m and the capacity of storage 2.50MMT(18.37MMbbl) the project approval cost Rs.1693 crores. It is four compartments is required each compartment 0.65MMT. The commencement of construction May 2010.

PHASE-II : (6.5MmT) under construction

- Chandikhole, Odisha - 4 MMT
- Padur, karnataka - 2.5 MMT (additional capacity)

V. INDIA'S OVERAL CAPACITY

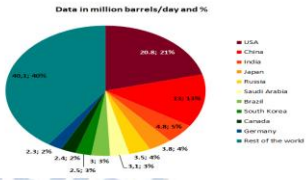
Phase-I can supply the requirement for 10days.

PHASE-II The Narendra Modi government has given in-principal approval for establishing underground crude oil storages in Odisha and Karnataka to increase emergency stockpile cover by 12 days to 22 days.add capacity for another 12days of requirement.

- Industrial reserve stock for 65days.
- So overall it comes to around 90days of safety stock (65+10+12=89)

WORLD' LARGEST SPR HOLDERS

China, USA, India largest oil consumers in 2018 show below the figer



- India is the world's third largest consumer of crude oil after US and CHINA
- 82% of the oil consumed in India is imported
- Crude oil import constitute around 25% of India overall import
- Oil import bill 2019 year US $111 billion around Rs 9lakh crore.

COMPLETION SCHEDULE

The completion schedule for the three terminals along with associated interconnecting facilities from the date of approval of the project

- Mangalore Terminal - 53 months.
- Vishakhapatnam Terminal - 51 months.
- Padur, Udipi Terminal - To be given after

This includes 9 months for preparation of bid documents and award of work on LSTK concept.

VI. CONCLUSION

India imports about 70% of its oil and gas requirements. Solid fuels are also partly imported owing to the poor quality of the solid fuels available here. The dependence on fossil fuels is increasing and by 2020, hydrocarbon requirement will increase by 90%. Hence, India is developing strategic storage facilities to meet short-term supply disruptions. In future there will be need to link these strategic storages to the existing refineries so that if a port gets blocked, supplies can be restored by the nearest storage. There is also need to develop the hydro, nuclear and solar energy industries for long-term solutions. Phase-I involves stocking of strategic reserves by government, and in future, phase-II will involve joint participation, in the form of public private participation (PPP) model. Presently, caverns are being constructed

for crude oil; in future, underground storage of products, compressed natural gas and liquefied natural gas will also be carried out. Salt caverns, in ground concrete tanks and other storage structures shall also be developed Presently Engineers India Limited has been entrusted the task of construction management, technology absorption and development. Indian Strategic Petroleum Reserves Limited (ISPRL), a wholly owned subsidiary of Oil Industry Development Board (OIDB) under the Ministry of Petroleum and Natural Gas is developing the human resources for operation, maintenance and oil trading, etc.

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