Terminal Vapor Recovery of Oil Tankers in China: Current Issues and Promotion Strategies

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Abstract: Terminal vapor recovery, a widely-applied technology for emission control on vapors of gasoline and other fuels at terminals, can effectively reduce the VOCs (volatile organic compounds) during the cargo loading procedure of oil tankers. This paper aims to provide a systematic analysis of the current situation and main issues of vapor recovery technology, proposals of basic principles, general strategies and specific tasks and programs for the promotion of the technology, as well as a reference for decision-making on the further development of terminal vapor recovery system in China.

1. Introduction
Petroleum products of relatively low saturation vapor pressure such as diesel and gasoline, from which large amounts of VOCs evaporate during storage, transportation, loading, unloading and other procedures, lead to environmental pollution and product damage. Vapor recovery system at terminals has been widely used for emission control across the world. The recovery of petroleum from VOCs, the main component arising from the evaporation of fuels, utilizing vapor recovery units is an effective measure for energy conservation and emission reduction, contributing to pollution mitigation and petroleum recycling.[1]

Today, countries including the US, the Netherlands, and South Korea already adopted the vapor recovery technology at terminals whereas China still lags behind. As a major shipping country in the world, China owns around 190 crude oil and refined oil terminals above 10,000 tonnage[2], and a throughput of crude and refined oil over 650million tonnes. Without pollution control, tens of thousands tonnes of VOCs are emitted into the atmosphere, damaging the ecology and health. A host of issues remains on the development of terminal vapor recovery system in China, an unclear future strategy included.

2. Terminal Vapor Recovery System
The terminal vapor recovery system consists of shore-based vapor recycling equipment, ship-to-shore connections, and vapor collection facilities. Vapor recycling equipment is based on shores and used for treatment of collected vapor, leveraging technologies ranging from absorption, adsorption, condensation to membrane separation. Ship-to-shore connections link ships with vapor recovery and treatment facilities with embedded safety and piping networks. Vapor recovery systems without safety measures pose risks to vapor recovery. Vapor collection system (VCS): According to the standards of shipbuilding in China, oil tankers above 30,000-tonnage are equipped with VCS for vapor recovery at terminals and those above 20,000-tonnage with Inert Gas Systems (hereinafter as “IGS”), which supports terminal recovery after simple adjustment. In China, few oil tanks below 20,000-tonnage are
connected to terminals by piping. Without enclosure in cargo tanks, vapor recovery at terminals requires a large amount of renovation. [3,4]

3. Current Situation and Main Issues
Many countries have adopted vapor recovery system at terminals. For example, several ports in the Netherlands and South Korea have made it compulsory through IMO (International Maritime Organization) Circular. The US and the European Union have introduced stringent emission standards and regulations for terminal vapor recovery. Norway, Japan and a few other countries are also shoring up efforts on that front [5].

In contrast, China is still in the early stage where absorption and adsorption are favored for cost effectiveness. In 2011, to accelerate the adoption of vapor recovery technologies, the Chinese Ministry of Transport designated Aoshan (crude oil port) and Yingkou Bayuquan (refined oil port) of Sinochem Oil Co. Ltd for demonstration projects on terminal vapor recovery. Five years later, the Chinese Ministry of Transport launched the first pilot project on terminal vapor recovery system, and Sinochem Oil was on the list. Today, Aoshan has established a vapor recovery system, but most facilities stay idle or suspended while the recovery system at Bayuquan is yet completed. Apart from demonstration and pilot projects, there emerged another 10 terminal recovery systems in China, which have hardly been commissioned for the following reasons: 1) **Can’t use it** due to inadequate standards and regulations. Many vapor recovery systems at terminals lack safety protection, creating exposures to malfunction. 2) **Don’t dare to use it** because of inflammable and explosive gases, culprits of prior accidents in China. 3) **Don’t want to use it** considering the high maintenance cost compared to non-guaranteed benefits from petroleum recovery. 4) **Don’t have the chance to use it** owning to the low utilization rate of recovery facilities caused by limited vessel infrastructure. In a nutshell, the main obstacles of vapor recovery investment are inadequate standards and regulations, high construction and maintenance cost, space-related installation difficulty, and inexperience [6-8].

4. Promotion of Terminal Vapor Recovery System
Complexity and workload considered, a hasty approach to scaling terminal vapor recovery system in China is not optimal, and neither is it applicable to every terminal. Therefore, it is recommended that the undertaking be guided with scientific deployment and prudent strategies in the principles of comprehensive planning, laws and regulations, science and technologies, as well as the coordination and collaboration of ministries, government agencies and the private sector.

**Implementation.** Begin with pilot projects in key regions of pollution control and gradually expand to other regions in later stages. First, select a few major ports for pilot projects covering the entire cycle from construction, operation, maintenance to monitoring. The experience accumulated could be translated into reference for policies and standards as well as operational and management models for Chinese circumstances. Start with larger ports of optimal infrastructure and oil transportation volume in key regions of air pollution control including Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta, and gradually include other ports in China.

**Management structure.** The collaboration of authorities in transportation, environmental protection, safety and supervision guarantees any issues arising from the implementation will be handled timely and properly. Authorities should strengthen communication with private entities operating at terminals through a platform for feedback and consultation.

**Operational mechanism.** Considering the import dependence and heavy investment in vapor recovery technology, financing and other forms of assistance are needed for the promotion of vapor recovery system. Meanwhile, a science-based framework of policies and standards is the pre-requisite of an orderly market. In the long term, the functioning of the vapor recovery ecosystem should be regulated by the market.

Specific tasks recommended are as follows:

**Comprehensive planning.** Terminal vapor recovery involves a number of sectors and relevant authorities. The establishment of nationwide vapor recovery system relies on the concerted efforts of all
stakeholders. Therefore, the top-level design is indispensable. It is more than necessary to formulate a comprehensive plan detailing general strategies, principles, objectives, measures and technical roadmap.

Emission standards. Emission standards serve as the baseline for the research and development of equipment and regulations. Authorities should accelerate the introduction of relevant emission standards tailored to the Chinese circumstances.

Safety Requirements. Vaporized petroleum is a special gas posing a certain degree of safety risks. Therefore, safety regulations must be in place for the maximum risk reduction. It is recommended that vapor recovery units be included in the scope of port safety management. Safety requirements on equipment manufacturing should also be further clarified. Operators should receive safety trainings on specialized procedures, work manual, contingency plan etc.

Market rules. Having the market play a decisive role in resource distribution helps to achieve the sustainability of terminal vapor recovery system. Relevant authorities should make more endeavors in research, supporting policies, and the establishment of a fair and orderly market. Profits should be distributed in proportion to investments. Policies should be updated to allow the circulation of recycled petroleum products.

Capacity building. Managers and operators in the vapor recovery system must be proficient with recovery processes, port procedures, equipment operations and contingency capabilities. Personnel responsible for system operation, supervision, management, inspection and testing should be certified or licensed.

Follow-up research. Follow up on vapor recovery pilot projects. Conduct a holistic analysis from the perspectives of technology, management and supervision covering design, construction, operations and other steps involved in the vapor recovery cycle. Issues identified can be elevated into experience. The research institute should forge an exchange forum with relevant departments for effective communication, technology advancement, policy, regulation and technical standard adjustment, contributing to the development of terminal vapor recovery system in China.

Research and Development. Consider the technical and management requirements of terminal vapor recovery system. Upgrade the system with advanced systemic design and key technologies from overseas. Strive for independent research and production of equipment and facilities. Improve the management system of terminal vapor recovery. Recommended research focuses include independent research and production of equipment and facilities for crude and refined oil ports, reduction of energy consumption and operational cost, and the establishment of a monitoring and evaluation mechanism for the safety of vapor recovery.

5. Conclusion

1) With an analysis of the current situation and main issues of the development of terminal vapor recovery system in China, the paper arrives at the conclusion that the obstacles restricting the adoption of the system are inadequate standards and regulations, high construction and maintenance cost, vessel-related installation difficulty, and subtype terminal infrastructure etc.

2) The promotion of terminal vapor recovery in China is an undertaking of high complexity; Therefore, it is not realistic to expect it to be completed within a short period of time. Rather, a realistically steady trajectory navigated by scientific deployment and comprehensive planning is recommended. Therefore, it is recommended to be guided with scientific deployment and prudent strategies in the principles of comprehensive planning, laws and regulations, science and technologies, as well as the coordination and collaboration of ministries, government agencies and the private sector. Begin with pilot projects in key regions of pollution control and gradually expand to other regions in later stages. The management structure should focus on the collaboration of authorities in transportation, environmental protection, safety and supervision. The operational mechanism should feature financial support in early stages and market-based regulation in the long term.

3) For the sound development of terminal vapor recovery in China, the paper proposes the following tasks: formulating a comprehensive plan, emission standards, safety requirements, technical guidelines,
market rules and regulations, as well as capacity building programs, follow-up research on pilot projects, and further research and development on vapor recovery technologies.

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