DOI: https://doi.org/10.36719/2663-4619/115/342-347

Tural Maharramov
SOCAR Downstream Management LLC
https://orcid.org/0009-0008-3457-0884
tural.mhr@gmail.com

Selection of Oil Spill Response Equipment for Onshore Operations

Abstract

The selection of appropriate oil spill response equipment is critical for effective containment, recovery, and remediation of spills occurring in onshore environments. Unlike offshore incidents, onshore oil spills often take place near sensitive ecosystems, industrial sites, or populated areas, requiring a rapid and well-coordinated response to minimize environmental and public health risks. This article explores key criteria for selecting response equipment tailored to onshore applications, including terrain conditions, spill volume, accessibility, and environmental sensitivity. The paper categorizes equipment into containment, recovery, storage, and cleaning technologies, and evaluates their suitability across various scenarios such as pipeline leaks, tank failures, and transport accidents. Additionally, the study highlights the importance of site-specific risk assessments and preparedness planning in guiding equipment selection. Emphasis is placed on the integration of innovative tools, such as sorbent materials, portable skimmers, vacuum systems, and bioremediation agents, as well as the role of training and drills in enhancing operational readiness. By providing a structured framework for equipment selection, this article aims to support environmental professionals, and emergency responders in improving the efficiency and effectiveness of onshore oil spill response strategies.

Keywords: *Oil spill response, onshore spill management, environmental protection, containment equipment, recovery systems, sorbents, vacuum trucks, skimmers, bioremediation, emergency preparedness, spill risk assessment, cleanup technologies, spill response planning, land-based oil spills, equipment selection*

Tural Məhərrəmov
SOCAR Downstream Management MMC
https://orcid.org/0009-0008-3457-0884
tural.mhr@gmail.com

Quruda əməliyyatlar üçün neft dağılmalarına müdaxilə avadanlığının seçilməsi

Xülasə

Quruda baş verən neft dağılmalarının qarşısının alınması, yığılması və ətraf mühitin bərpası üçün düzgün cavab avadanlıqlarının seçilməsi son dərəcə vacibdir. Dənizdəki hadisələrdən fərqli olaraq, quruda baş verən neft sızmaları tez-tez həssas ekosistemlər, sənaye obyektləri və ya sıx məskunlaşmış ərazilər yaxınlığında meydana gəlir ki, bu da ətraf mühitə və ictimai sağlamlığa ciddi risklər yaradır. Bu məqalədə, yerli şəraitə uyğun cavab avadanlıqlarının seçilməsi üçün əsas meyarlar – ərazi şəraiti, sızma həcmi, əlçatanlıq və ekoloji həssaslıq – araşdırılır.

Tədqiqatda avadanlıqlar dörd əsas kateqoriyaya bölünür: məhdudlaşdırıcı (bumlar, baryerlər), bərpaedici (sorbentlər, portativ skimmerlər), müvəqqəti saxlama və təmizləmə texnologiyaları. Bu kateqoriyalar müxtəlif hadisə ssenariləri – boru kəmərlərinin sızması, çən nasazlıqları və nəqliyyat qəzaları – kontekstində qiymətləndirilir. Məqalədə, avadanlıq seçimini istiqamətləndirmək üçün sahəyə əsaslanan risk qiymətləndirməsinin və hazırlıq planlarının əhəmiyyəti vurğulanır.

Eyni zamanda, müasir yanaşmalara – sorbent materiallar, portativ vakum sistemləri, bioremediasiya vasitələri – və cavab komandalarının operativ hazırlığını artırmaq üçün təlim və məşqlərin rolu da diqqət mərkəzindədir. Bu məqalə, ətraf mühit mütəxəssislərinə, və fövqəladə hallar üzrə cavabdeh qurumlara quruda baş verən neft dağılmalarına qarşı mübarizədə avadanlıq seçiminin daha səmərəli və effektiv həyata keçirilməsi üçün strukturlaşdırılmış yanaşma təqdim etməyi hədəfləyir.

Açar sözlər: *Neft dağılmalarına reaksiya, quruda dağılmaların idarə edilməsi, ətraf mühitin mühafizəsi, saxlama avadanlığı, bərpa sistemləri, sorbentlər, vakuum maşınları, skimmerlər, bioremediasiya, fövqəladə hallara hazırlıq, dağılma riskinin qiymətləndirilməsi, təmizləmə texnologiyaları, dağılmaya cavab planlaması, quruda neft dağılmaları, avadanlıq seçimi*

Introduction

Oil spills continue to pose significant environmental and socio-economic challenges worldwide, particularly in regions with extensive oil exploration, production, and transportation infrastructure. While offshore oil spills often receive greater attention due to their transboundary nature and visual impact, onshore oil spills are equally detrimental, especially when they occur in populated areas, agricultural zones, or near ecologically sensitive sites. The impact of such spills can result in soil degradation, groundwater contamination, loss of vegetation, and long-term ecosystem disruption (Fingas, 2011).

Unlike marine environments, onshore terrains present a wide range of challenges for spill response teams, including limited accessibility, variable soil permeability, and land-use constraints. The nature and severity of the spill, combined with the site's topography and climatic conditions, significantly influence the selection of appropriate response strategies and equipment (ITOPF, 2020). Timely and effective response depends on having the right tools that are both suitable for the specific environment and adaptable to various scenarios such as pipeline leaks, tank overflows, or transport accidents (Al-Majed et al., 2012).

The selection of oil spill response equipment must therefore be guided by multiple factors, including the volume and type of oil, the response time window, and environmental sensitivity. Equipment categories—ranging from containment barriers and recovery systems to bioremediation agents and absorbent materials—must be selected based on a comprehensive risk assessment and preparedness planning framework (NOAA, 2014). Furthermore, international best practices emphasize the integration of site-specific characteristics into equipment planning to enhance response efficiency and environmental outcomes (IPIECA-IOGP, 2015).

This paper aims to explore the classification, suitability, and strategic deployment of oil spill response equipment specifically tailored for **onshore environments**. By referencing real-world incidents, scientific research, and internationally recognized guidelines, this study provides environmental professionals and emergency planners with a practical framework for improving onshore spill response capacity (Abdullah, Rahmah, Man, 2010).

Some spill response equipment

Oil spill response operations are typically categorized into Tier 1, Tier 2, and Tier 3 levels, each requiring a corresponding scale of equipment and response capacity (IPIECA-IOGP, 2015). Tier 1 covers small, localized spills that can be addressed with on-site resources. Tier 2 involves medium-scale spills requiring regional support, while Tier 3 encompasses large-scale, often transboundary spills that demand national or international coordination (Azercosmos, 2023).

Oil spills can vary widely in volume, location, and impact potential, requiring a scalable and adaptable inventory of response equipment. These operations are often classified into **Tier 1 (local), Tier 2 (regional), and Tier 3 (national/international)** incidents, each necessitating a different scale and sophistication of response assets (IPIECA-IOGP, 2015).

To ensure operational readiness across all tiers, response plans must include the following essential equipment categories:

- **Vacuum Trucks**: These are vital for recovering oil from paved surfaces, soil, and containment zones. Equipped with powerful suction systems, they are particularly useful in urban or industrial areas where quick removal is essential to prevent spreading or infiltration into drainage systems.
- **Transfer Pumps**: Once oil is collected, transfer pumps are employed to move the recovered oil from skimmers, berms, or temporary storage pools into containment tanks or vacuum trucks. Their portability and high flow rate capabilities make them ideal for field operations.
- **Vacuum Brooms for Shadow Areas**: These specialized tools are designed to access difficult or shaded areas—such as under pipelines, beneath structures, or along wall edges—where standard skimmers or trucks cannot reach. Their use ensures thorough collection of residual oil and reduces post-spill contamination risks.
- **Star Tanks (Collapsible Storage Units)**: Star tanks provide temporary, flexible storage for recovered oil during field operations. Made of durable, chemical-resistant materials, they can be quickly deployed and are especially useful in remote or uneven terrain where fixed tanks are unavailable. Their foldable design supports rapid mobilization and space-efficient transportation.
- **Containment Booms and Sorbents**: Booms are used to restrict the movement of oil, particularly in waterways or drainage channels, while sorbents—such as pads, rolls, and loose fibers—absorb and retain oil for safe disposal.
- **Portable Skimmers**: For areas where standing oil is present, portable skimmers (e.g., weir, drum, or brush types) are used to recover oil before it seeps into the ground or evaporates. They are effective for surface recovery in pits, tanks, or natural depressions.
- **Bioremediation Agents**: Following mechanical recovery, biological treatments can be applied to accelerate the natural breakdown of residual hydrocarbons in soils and sediments, especially in ecologically sensitive zones (Brekke, Solberg, 2005).

Main equipment for onshore oil spill response operations

Ensuring that this equipment is **pre-positioned** near high-risk sites—such as pipeline corridors, refineries, and storage terminals—is a best practice for minimizing response time and operational delays (ITOPF, 2020).

Enhancing Response Efficiency through Innovation

In addition to traditional response tools, the incorporation of **emerging technologies** significantly enhances operational effectiveness. These innovations optimize resource allocation, improve data-driven decision-making, and reduce the environmental footprint of response activities (Choi, Cloud, 1992).

Key advancements include:

- **Remote Sensing and UAVs**: Real-time monitoring using drones and satellite imagery allows for early spill detection, accurate spill mapping, and situational awareness. UAVs are particularly effective in inaccessible or hazardous areas.
- **Smart Equipment**: Sensors embedded in booms, skimmers, and pumps can monitor oil thickness, equipment functionality, and environmental parameters, feeding data into command centers for adaptive operations.
- **AI-Powered Spill Modeling**: Machine learning models can simulate spill movement based on weather, topography, and spill volume, helping responders deploy resources more strategically (Zhang et al., 2020).
- **Eco-Friendly Sorbents and Additives**: Innovations in biodegradable sorbent materials and non-toxic dispersants support environmentally conscious response efforts.
- **Digital Response Platforms**: Centralized dashboards integrating real-time data from field sensors, GPS-tracked equipment, and weather models improve inter-agency coordination and transparency.

By combining **proven mechanical methods** (e.g., vacuum recovery, containment, and storage) with **modern technological enhancements**, oil spill response operations can be transformed into efficient, precise, and environmentally responsible interventions.

Training and Regular Drills: Ensuring Operational Readiness

The successful deployment of oil spill response equipment is not solely dependent on the availability of the right tools—it also requires well-trained personnel who are capable of using the equipment effectively under pressure. **Training and regular emergency response drills** are fundamental components of any oil spill preparedness strategy. These activities ensure that response teams are proficient in equipment handling, understand safety protocols, and can coordinate actions efficiently during real incidents.

1. Importance of Hands-On Training

Personnel must receive comprehensive, hands-on instruction in the use of key oil spill response equipment, including:

- **Vacuum trucks and trailers**: Operators must be trained in suction strength calibration, safe operation near sensitive areas, and proper handling of recovered oil.
- **Transfer pumps**: Users should understand correct setup, flow rate adjustment, and emergency shut-off procedures.
- **Star tanks**: Teams must practice tank unfolding, anchoring, and sealing techniques to prevent leaks or collapses.
- **Boom deployment and retrieval**: Effective containment requires coordination, correct anchoring, and response to wind and current conditions.
- **Skimmer operation**: Understanding oil thickness, skimming speed, and waste separation processes is crucial for maximizing recovery.

Training should also cover **personal protective equipment (PPE)** usage, **waste management procedures**, and **post-operation decontamination** of tools and personnel.

2. Simulation Drills and Field Exercises

Regular simulation drills allow organizations to assess readiness, identify gaps in equipment or skills, and refine communication protocols. Drills should be **tiered**, reflecting different response levels:

- **Tier 1 drills** simulate localized spills, often with on-site equipment and a limited number of responders.
- **Tier 2 exercises** incorporate multiple agencies and simulate regional coordination, including the use of external equipment depots.
- **Tier 3 drills** involve national or international collaboration, full-scale deployment, and simulated crisis management scenarios.

Realistic drills should also simulate **difficult environmental conditions**—such as nighttime operations, inclement weather, or difficult terrain—to ensure response capacity under varied scenarios.

3. Integration of Technology into Training

Modern training programs increasingly incorporate **virtual reality (VR) and augmented reality (AR)** for equipment simulation and scenario-based learning. These technologies allow responders to:

- Practice boom deployment or vacuum truck operation in a risk-free digital environment.
- Engage in interactive spill simulations with real-time decision-making feedback.
- Receive remote training in hazardous or logistically difficult regions.

Online learning modules, mobile apps, and video tutorials also serve as **cost-effective and scalable tools** for ongoing learning.

4. Certification and Compliance

Participation in training and drills should be **formally documented** and linked to industry certification requirements (e.g., IMO, OSHA, IPIECA). Organizations should maintain detailed records of personnel qualifications and ensure refresher courses are conducted at regular intervals.

Additionally, **third-party audits** and **government-mandated exercises** help validate preparedness levels and enforce regulatory compliance.

Conclusion

The comprehensive provision of oil spill response equipment—including specialized tools like vacuum trucks, transfer pumps, and collapsible storage tanks—significantly enhances operational readiness and response outcomes. When paired with advanced technologies such as remote sensing, AI-driven analytics, and smart monitoring systems, these tools offer a robust framework for managing spills across diverse onshore environments. As energy operations expand and environmental risks intensify, investment in both traditional and innovative response strategies is essential to ensure sustainable and effective oil spill management.

Well-maintained equipment is only as effective as the teams that operate it. A culture of preparedness—fueled by **regular, realistic training and drills**—is essential to minimizing the impact of oil spills. By combining **technical proficiency**, **team coordination**, and **adaptive learning technologies**, organizations can ensure rapid, safe, and efficient responses when incidents occur.

References

1. Abdullah, M. A., Rahmah, A. U., & Man, Z. (2010). Physicochemical and sorption characteristics of Malaysian cotton fiber sorbents for oil spill cleanup. *Industrial Crops and Products, 32*(3), 533–538. https://doi.org/10.1016/j.indcrop.2010.07.019
2. Azercosmos. (2023). *Remote sensing services for environmental monitoring*. https://azercosmos.az
3. Al-Majed, A. A., Adebayo, A. R., & Hossain, M. E. (2012). A sustainable approach to controlling oil spills. *Journal of Environmental Management, 113*, 213–227. https://doi.org/10.1016/j.jenvman.2012.08.003
4. Brekke, C., & Solberg, A. H. S. (2005). Oil spill detection by satellite remote sensing. *Remote Sensing of Environment, 95*(1), 1–13. https://doi.org/10.1016/j.rse.2004.11.015

5. Choi, H. M., & Cloud, R. M. (1992). Natural sorbents in oil spill cleanup. *Environmental Science & Technology, 26*(4), 772–776. https://doi.org/10.1021/es00028a018
6. Fingas, M. (2011). *Oil spill science and technology: Prevention, response, and cleanup*. Gulf Professional Publishing.
7. IPIECA-IOGP. (2015). *Tiered preparedness and response: Good practice guidelines*. International Petroleum Industry Environmental Conservation Association. https://www.ipieca.org
8. ITOPF. (2020a). *Response to oil spills in the terrestrial environment*. International Tanker Owners Pollution Federation. https://www.itopf.org
9. ITOPF. (2020b). *Contingency planning and response to oil spills*. International Tanker Owners Pollution Federation. https://www.itopf.org
10. NOAA. (2014). *Oil spill response: Tools and techniques*. National Oceanic and Atmospheric Administration, Office of Response and Restoration. https://response.restoration.noaa.gov
11. Zhang, Y., Zhao, J., Wang, H., & Yang, D. (2020). A review of oil spill modeling using computational methods. *Marine Pollution Bulletin, 155*, 111126. https://doi.org/10.1016/j.marpolbul.2020.111126

Received: 22.01.2025
Accepted: 01.03.2025