INDUSTRIAL AND LOGISTICS ACCIDENTS – CASE STUDY

STUDY 6/A – NORMAL SYSTEM

1. Starting position

In the event of a failure or structural damage to an industrial tank, large quantities of oil can suddenly be released into the environment, and **rapid immobilization is critical**, especially in industrial sites, refineries, warehouse bases and logistics hubs.



The severity of the event is increased by the following factors:

- **Large amount of oil spillage** (up to several tons, typically 10-100 m³), which triggers intensive soil infiltration in a short time;
- **Soil-type-dependent spreading**, especially in the case of porous, sandy or heterogeneous soils, where vertical infiltration can reach a rate of 0,5 to 1 m/h;
- **The presence of nearby infrastructure and populated areas** (sewer systems, building foundations, technological pipelines), which creates secondary risks, especially in the form of groundwater pollution;
- **Environmental sensitivity**, especially in the case of shallow groundwater, surface waters or close proximity to agricultural areas where health and ecological risks are significant.

The primary goal of the intervention is **to quickly immobilize large quantities of oil on the soil surface** and to protect deeper soil layers and groundwater, in accordance with current regulations (EU Soil Framework Directive, OSHA regulations). As a reference case, the **2010 Kalamazoo River oil spill can be mentioned**, where about 3000 m³ of oil was released into the environment and the total remediation cost exceeded **1.2 billion USD**, after more than five years of recultivation.

2. Nature of pollution (normal system)

- Rapid **vertical and horizontal infiltration of oil** into soil layers, with a combination of gravitational and capillary effects (0.1-1 m/h);
- **accumulation of hydrocarbons and PAH compounds** in soil pores, causing long-term soil toxicity;
- **Risk of groundwater contamination** if the oil reaches the aquifers (typically at a depth of 5–10 m);
- Secondary surface dispersal through precipitation and surface runoff.

Pollution typically takes the form of crude oil or refined products, which, despite their hydrophobic properties, partially dissolve over time, making treatment difficult and causing **permanent damage to soil biology** (20-40% reduction in microorganisms, up to 30% reduction in soil fertility).

3. Traditional methods of intervention

3.1 Localization

- Physical barriers (sandbags, temporary barriers);
- Creating trenches and cuts to stop infiltration.

Limitations:

- Deeper infiltration is not completely prevented (efficiency 50-70%);
- Precipitation or soil movement can break through the localization;
- During the time-consuming installation, the contaminated area grows rapidly.

3.2 Surface removal

- Mechanical dredging, vacuum suction;
- Use of mineral and synthetic absorbents (perlite, zeolite, vermiculite, PP).

Limitations:

- Loss of efficiency due to water absorption (30-50%);
- Dredging stirs up the soil, increasing infiltration;
- A large amount of contaminated soil is generated with a high disposal cost

3.3 Surface and structure treatment

- High pressure washing, detergents;
- Bioremediation or complete soil replacement.

Limitations:

- Spreading oil during washing;
- Slow biodegradation (3-6 months);
- High-cost soil replacement and logistics.

4. Operational challenges

- Extremely **narrow time window** for intervention;
- Multi-stakeholder coordination and administrative delays;
- Soil type-dependent, difficult-to-model spread;
- Rapidly increasing total costs (on average between €1 million and €10 million per case).

5. Result - normal system

- Partial immobilization (60–80%);
- Long post-cleaning and recultivation time;
- High waste and treatment costs (up to 40%);
- Permanent soil and groundwater damage with long-term ecological losses.

STUDY 6/B - EXOLINE® OIL STOP

1. Starting position

The baseline event is the same as described in Study 6/A. The **purpose of using Exoline® Oil Stop is not to replace traditional interventions**, but **to improve their material and functional effects**, especially in the case of large-scale industrial oil spills.

The main objectives are:

- Immediate hydrophobic immobilization **of large quantities of oil**;
- Significant reduction of infiltration into the soil;
- Long-term protection of soil and groundwater.

The **properties of Exoline® Oil Stop** (hydrophobic water repellency, air permeability, low specific gravity 0.65 kg/dm³, high specific surface area up to 26 m²/g, particle size >4 μm, alkaline pH 11.5–12.5) make it particularly suitable for rapid and controlled application in industrial environments.

2. Nature of contamination with Exoline®

- Infiltration **can be reduced by 50-70%**;
- Simultaneous stabilization of soil layers is realized;
- The breathability property supports the natural drying and regeneration of the soil.

3. Improved intervention methods
3.1 Localization with Exoline®

- Conventional barriers with zones enhanced with **Exoline®** (e.g. perlite + 20% **Exoline**).

Result:

- Hydrophobic adsorption immobilization (up to 10× capacity);
- Reduce infiltration by ~70%;
- Localization efficiency up to 90%.

3.2 Surface removal – improvement of absorbents

- **Exoline®** prevents water saturation;
- Oil selectivity improves;
- Air permeability ensures the stability of the soil.

Result:

- Waste Amount -50%;
- Faster, more efficient treatment;
- Spread reduction by up to 80%.

3.3 Surface and structure treatment

- Pre-wash **Exoline®** treatment;
- Stabilization by heat treatment (stable up to 370°C).

Result:

- Toxicity -70%;
- Protection of groundwater;
- Mobility reduction ~90%.

4. Operational impact

- Reaction time -40 -60%;
- Fewer intervention steps;
- Simplified logistics;
- Significantly lower cost level.

5. Result - improved system

- Immobilization efficiency ~90%;
- Faster recovery;
- Waste and CO_2 load -30%;
- Significantly reduced ecological risk (10-20%).

Final Note

The study presents a subsequent technological comparison. **Exoline® Oil Stop** was not used during the events referred to; its purpose is **to demonstrate the material improvement potential of existing systems in the event of industrial accidents**. It is recommended to launch pilot projects in real-world industrial environments, with quantitative cost-benefit and environmental impact assessments, in line with the EU Soil Framework Directive and OSHA regulations.