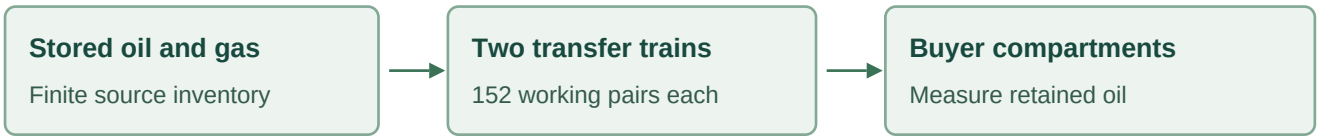
Emergency crude transfer and containment

The Haven Protocol is designed to keep crude moving to a buyer that can physically retain it after normal transfer fails. Its emergency duty is 400 reference m³/h of on-spec oil for 72 hours, or 40% of a 1,000 m³/h line. A total loss calls for isolation and containment.



Requirement	Simulation result
Recoverable damage	At second 80 one buyer failed while its weights stayed falsely healthy. With a truthful independent liquid witness, a primed spare and a 3 s switch, the 72 h lower bound across rolling 60 s windows was 400.03 m³/h.
Limit new transfer into a failed buyer	Two false weights allowed 1,442.857 L across the paired original inlets. With an independent liquid-level witness and 20 ms segmented seats, the paired main crossing fell to 8.539 L. One failed inlet admitted 4.276 L including its supplementary feed. It retained zero.
Total-loss containment	With both loaded yards confined to their assigned bays, the protected-joint exterior screen was 0.999953 L. A short path through a shared seam exceeded the combined 1 L limit.
Installation verdict	All 20 original source schedules replayed. Zero complete installations are verified. The study uses simulated data and assumed equipment properties.

What the automatic protection reads

The system compares inlet motion with the physical rise of oil in the receiving compartment. It also reads independent coupling position, valve closure, product quality, pressure, stored energy and tank capacity. A loss of trustworthy evidence calls for isolation.

How to read the results

Genuine delivery is new on-spec oil retained by a capable buyer. Crossing counts all forward oil at the original failed inlet. Captured oil remains inside the installation. Exterior oil includes modeled surface trace, liquid and vapor-equivalent losses across both yards.

How an unannounced loss unfolds

Two trains each operate with 152 working piston pairs and eight unavailable. In this fault, oil is already crossing the original buyer inlet at 75 hot L/s per train. A pair of false weight signals can persist while the actual destination stops retaining oil.

Physical event	Automatic response and outcome
Fault at second 80	A mechanical follower at the receiver detects the missing change in oil level after 39.75 ms. An independent dry coupling link detects physical loss of alignment. An internal diversion can leave that link aligned.
Isolate the original inlet	Two spring-return seats close on opposite faces of the same inlet. A captive coupling waits for both seats and a purge stroke. The 0.5505 hot L joint charge per inlet has a sealed catch, seller return and a separate finite quarantine cylinder.
Open a proven spare	An independently primed chamber supplies the original positive-flow demand while the fresh source switches. Each installation has a 250 reference L working prime and a separate recovery stroke. A 3 s peak transfer calls for 214.286 L.
Continue genuine receipt	A supplementary supply at each buyer starts with 14.4 reference m³ of net on-spec oil. Only the healthy buyer’s continuous 0.20 m³/h stream earns receipt. The spare has a 30 ms opening ramp in the modeled transfer.
Check the future destination	Oil enters a local low-pressure chamber at the working buyer. A separate lift pump moves it to reserved tank space. The buyer must retain the oil; moving its pre-existing heel earns no new sale.

Original inlet controls	Gross forward crossing
False weights alone, both buyers fail	1,442.857 reference L, paired
Both seats closed before planned release	0 L after separation
False weights, 39.75 ms local observation, 20 ms segmented seats	8.539 L paired main. One failed inlet admitted 4.269 L main plus 0.007 L supplementary oil.
Late local observation at 80 ms, or both seats jam with drive unloading	7.154 L or 9.691 L, respectively, into one failed inlet including supplementary oil.
Upstream seat jams alone	The predicted negative absolute pressure invalidates the single-phase calculation. Crossing and closure are unresolved.
Both physical proofs mimic the healthy state	1,437.143 reference L, paired over 10.1 s

Why the transfer cannot always be zero

At the native peak, one failed inlet admits 2.839 L before a trustworthy indication arrives at 39.75 ms. The selected seat calculation gives a minimum of 99.319 kPa absolute, 8.495 kPa maximum differential and 2.791 hot L of relief per arm. The healthy open seat retains only 65.7 Pa of headroom at a loss coefficient of 2.7. A coefficient of 5 fails.

What sustains a 72-hour transfer

Each standby yard has a 24 m radius tank with 15,000 reference m³ of available receiving space, a separate local chamber, 90 m of 400 mm header and independently powered lift equipment. A failed tank adds no receiving capacity.

Operating check	Selected result	Failure control
Rolling 60 s delivery	400.03 m³/h at 3 s	393.665 m³/h lower bound at 5 s. A half-rate supplementary feed gives 399.930 m³/h.
Lift and storage	2.183 m³ peak chamber oil; 359.6 hot m³ tank space left	A delayed lift or a blocked header can fill the local chamber and interrupt receipt.
Stored electricity	690.8 kWh available; 636.5 kWh required	One available bay has a 281.7 kWh deficit. Battery heat, contact and actual state of charge matter.
Fast header closure	692.8 kPa absolute; 1,000 kPa assumed rating	The 350 kPa option fails. An always-open absorber produced nonphysical negative absolute pressure on the finer mesh.
Supplementary feed	24 mm bore; 22 mm effective diameter with deposits	At 0.5 Pa·s and 22 mm, 2.75 kPa remains after regulation. At 1.0 Pa·s the same path misses by 17.65 kPa.

Energy and pressure hardware

The selected electrical case uses two connected bays with two 257 kWh battery modules apiece. It assumes 80% initial battery health and a usable state-of-charge range of 12–96%. The pressure-rated header, end seats and anchors carry the initial closure wave. An isolated return recovers compressed oil after flow stops.

Product quality at custody

All 27,152 upstream lot tests passed the composition model. A buyer tank starting at 0.5% water gave 0.5165% in the first 44 m³ mixed lot. Starting at 5% gave 3.9569%, above the 1% limit. Also verify chloride at or below 5 mg/kg and sediment at or below 0.05% by mass. Quarantine the lot when the independent sample or reference is unreliable.

Oil held by the segmented seats

After 1,016 exchanges, a 20 µm oil film with 99% recovery leaves 0.442 reference L in reserve per arm. The coupled material balance gives 400.029 m³/h. A 50 µm film exhausts the reserve by 0.075 L per arm even though the one-minute rate clears 400.

Segmented seats and a five-second takeover

A 500 reference L prime and four isolated 0.20 m³/h lines per yard feed a separate 75 hot m³ standby buyer tank. With surface and film losses charged, 6,000 failure phases per trial gave a nominal 400.829 m³/h. At 100 ms notice, 80 ms opening, a 5 s switch and one added line lost, 8.583 L crossed the failed inlet and the healthy receiver sustained 400.264 m³/h. At 160 ms notice and 110 ms opening, crossing rose to 12.872 L and flow fell to 399.942 m³/h. Half the start gas also fails. Tank acceptance and containment need joint testing.

Where the oil and displaced gas go

A covered pair of spill bays surrounds each original receiving yard and its standby. The 5.25 m retaining wall has no low-level exterior drain. Beneath the floor, two steel skins enclose monitored dry compartments. Separate gas holders accept displaced air and vapor.

72-hour receiver control	Paired exterior result or limit
Original and standby stock in assigned bays; drains and passages closed	0.999870 L. No liquid overtopped. The higher bay level reached 4.63 m.
One 10 µm through-defect per yard in solid 140 mm joint belts	0.999940 L. The limit is 1 L total for both yards.
Same defects in ordinary 36 mm plate or a 12 mm common seam	1.000141 L and 1.000683 L, respectively.
Both cargoes reach one blocked bay	13,423 m³ of liquid overtops per yard. Oil fraction requires separate accounting.
All vapor connections blocked	91.0 kPa gauge against a 6 kPa assumed limit. Exterior release is unresolved once that limit is exceeded.
Thermal water escapes both barriers	1.464952 L. The added water can carry 0.465 L of oil-equivalent impurity at the specified concentration.

What the one-litre result requires

The site trace begins near 0.999798 L before new surface and leakage charges. The calculation assumes bounded surface cleanliness, wetting, flaw count and length in both yards. A common tear, spray over the wall, loss of vapor containment or leakage outside the two yards can exceed the allowance.

Construction scale

The modeled tertiary enclosure is 185 × 100 m per yard, with four proposed 45 m diameter variable-volume gas holders per train. The roof calculation alone uses 44,400 t of concrete across both yards. No installed assembly or construction price establishes commercial viability.

Thermal control and construction

The paired excavation limit applies to both trains and their supporting yards. Pressure depends on absolute gas charge, water temperature and the amount of coolant actually retained.

Site or utility check	Outcome
Hot-water margin	3.476 kPa under nominal conditions. At reduced barometric pressure and low fill, 1.403 kPa remains against a 1.33 kPa target.
Backing cassette loses water	0.232 kPa; cases 12, 18 and 19 miss the pressure target.
Thermal collector	A separate 413.20 m³ water catcher per train leaves 14.60 m³ under its modeled expansion and standpipe load. The extra water adds 310.05 m³ per train.
Excavation limit of 72.2 million m³	With the thermal cassette and tertiary guard, 72,189,068 m³ nominal. The adverse top-down case reaches 72,201,534 m³ at 15 mm mean surface preparation.
Foundation and surface response	Lower friction, failed anchorage or unexpected surface removal can consume the margin. Installed soil, welds, pipe restraints, media and room for construction have not been demonstrated.

Qualification work

Test independent receiver closure and single- and double-jam behavior at operating temperature. Meter every outlet during an isolated 72 h run with deliberately false local readings. Test finite tank free volume, loaded shutoff, vapor paths, thermal capacity, pressure-holding equipment, liner assemblies and surveyed foundations together.

What operators can verify here

The console displays modeled case duties, required actions, confidence limits and recorded results. Operational use would require independent, time-synchronized field records of retained inventory, inlet crossing, pressure, battery health, product grade, gas path and exterior collection. No live plant is connected.

Roof and thermal alternatives

A second layout puts the gas expansion volume directly above each loaded bay. A separately powered cooling loop provides another way to protect hot-water pressure. Each modification has its own failure tests.

Alternative	Conditional result and adverse control
Add a 1 L spring diaphragm between the inlet seats	With the upstream seat jammed, this option gave 88.693 kPa absolute, 33.086 kPa differential and 4.397 L crossing. Tenfold inertia gave 12.134 kPa and failed. With healthy seats, crossing was 4.293 L.
Move two gas bells above each yard	With all external gas connections lost, two independent moving roof bells held peak pressure to 2.699 kPa gauge. A 20 s fill reached 4.293 kPa against 6 kPa.
Bell motion is restricted	A jammed bell gave 661 kPa in its isolated bay, far outside the design envelope. An 8 m travel limit gave 72.14 kPa; abrupt gas heating gave 9.03 kPa. Moving seals and roof-ring foundations require verification.
Active cooling with the original 50 mm water layer	At a true 88°C start, a functioning pump with 15 min takeover gave 1.824 kPa water margin. At 30 min with weaker thermal contact it gave 1.821 kPa. Complete loss of the loop gave 0.296 kPa; cases 12, 18 and 19 missed 1.33 kPa.
Independent cooling assets	Each train needs 1,800 t of ice, a 2,000 m³ meltwater bund and dedicated circulation power. Only 0.565 m³ remains in the 56.05 m³ loop catcher after expansion. Total escape of the loop and meltwater could carry 2.779 L of oil, paired.
Construction scope with cooling at original floor grade	All-face work gives 72,200,521 m³, 521 m³ over the cap. Floor-only credit and floor-only surface truing gives 72,199,413 m³, 587 m³ below it. Original six-face liner credit with floor-only truing gives 72,195,537 m³. A survey must establish the actual scope.
Raised real floors	Raising the usable floor patches gave 72,199,957 m³, leaving 43 m³. At a true 88°C start its minimum water margin was 0.621 kPa. Cases 12, 18 and 19 fail.
Alternative vault at original process-floor grade	The profiled buyer vault gives 72,199,724 m³, 276 m³ below the cap. Its 6,103 m² of new developed skin creates at least 24,413 m² of additional guard surfaces. The 1 L exterior and water limits require verification on this geometry.

Separating fluids at the buyer

Under the water-cassette layout, wetted groups gave 0.698767 L/h of modeled water ingress against the 0.699 L/h limit. A common wet connection across all guard surfaces gave 0.700951 L/h. The incoming product, the original stored heel, retained spill and exterior contamination require separate records.

Cases requiring immediate isolation

Nine cases require both original buyer inlets to stay isolated from onset. All nine replayed zero post-stop source transfer. A scheduled closed inlet provides no test of live mid-flow detection.

Case	Specified condition	Required duty	Installation
01	Source closing energy lost and conventional valves jammed	Isolate at onset	Unverified
02	Terminal closing energy lost and conventional valves jammed	Isolate at onset	Unverified
03	Source and terminal closing energy lost with jammed conventional valves	Isolate at onset	Unverified
04	Trigger inlets blocked with jammed conventional valves	Isolate at onset	Unverified
05	Pilots blocked with jammed conventional valves	Isolate at onset	Unverified
06	Sleeves torn with jammed conventional valves	Isolate at onset	Unverified
07	Sleeve closing force tripled with jammed conventional valves	Isolate at onset	Unverified
08	5 mm² seat gaps with jammed conventional valves	Isolate at onset	Unverified
11	Closed catch boundary lost	Isolate at onset	Unverified

Case evidence

Each original clock ran under both 73% / 100% gas assignments and both pressure rules, with eight piston pairs down per train. The complete replay covers 691,200 train-minutes. The operator panel identifies the unresolved gates for each case.

Cases requiring delivery

Six cases require all 72 hours. Five require flow for 60 hours followed by 12 hours of isolation. Across positive-duty schedules the source floor was 403.492 m³/h and the clock-aligned qualified oil result was 400.151 m³/h.

Case	Specified condition	Required duty	Installation
09	Three route boundaries lost	72 h service	Unverified
10	Independent heat envelope penetrated	72 h service	Unverified
12	Loaded collapse and outer-vault loss at 60 h	60 h then isolate	Unverified
13	100 mm source-gas wall breach	72 h service	Unverified
14	Gas heat transfer degraded	72 h service	Unverified
15	Catch heat transfer reduced at 60 h	60 h then isolate	Unverified
16	Local pocket outer boundary lost	72 h service	Unverified
17	Catch heat transfer lost at 60 h	60 h then isolate	Unverified
18	Enclosure gas starts at 86°C	60 h then isolate	Unverified
19	Catcher shield fully open	60 h then isolate	Unverified
20	All current quality evidence falsified	72 h service	Unverified

Case evidence

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