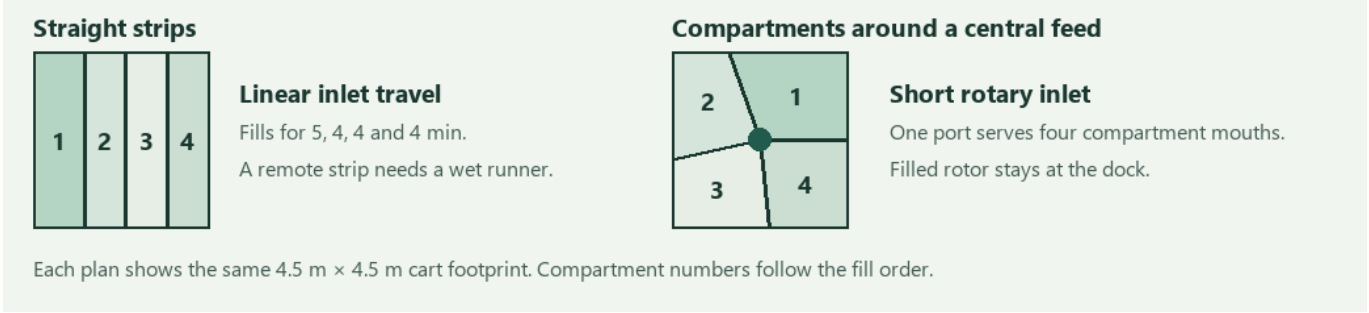
Four-strip buyer receiver

A buyer-side mechanical follower compares oil entering the original inlet with oil rising in the receiving cart. Its purpose is to stop an unexpected diversion automatically while allowing genuine delivery to an intact buyer.

Decision

The broad tank admitted 21.409 L after both buyers failed. Four strips and a seller-side bellows reduced the local result to 10.980 L. The compact four-sector feed with its connecting elbow admitted 11.676 L. Both weight readings stayed falsely healthy and neither buyer retained oil. All 20 complete missions remain unverified.

How oil reaches the four compartments



Each plan shows the same 4.5 m × 4.5 m cart footprint. Compartment numbers follow the fill order.

Fill one compartment at a time

The 4.5 m square buyer cart fills four final compartments for 5, 4, 4 and 4 minutes. The selector changes compartment only in dry intervals after minutes 5, 9 and 13. Full compartments close. The straight-strip layout and the compact radial layout keep the same buyer inlet.

Trip on missing liquid

A mechanical follower rides on the active strip. Its smaller surface gives greater vertical movement for each litre received. At the test onset, the five-minute strip commanded closure after 39.75 ms. The seat took another 80 ms to move. A 12 L spring bellows per seller accepted oil upstream during that movement.

Read the three volumes separately

In the local straight-strip test, 5.679 reference L crossed both inlets before the command and 5.301 L afterward. The seller-side bellows separately received 2.778 hot L. The model converts 1.05 hot L to one reference litre. Oil escaping the site requires its own boundary measurement.

Why a sudden flowing loss still passes oil

At 400 reference m^3/h, a required minute contains at least 400/60 m^3. Divide that minute into 3,000 intervals of 20 ms. At least one contains 2.222 L or more. If both buyers fail at the start of that interval and the inlet flow remains unchanged for 20 ms, at least that much crosses. At the tested 75 hot L/s per buyer, 20 ms carries 2.857 reference L. Advance closure can achieve zero during a mechanically controlled disconnect.

Healthy operation has a minimum tolerance

At 75 hot L/s into the 4.758 m^2 strip, a 15 ms lag plus 0.10 mm position error implies 0.336 mm apparent mismatch, below the 0.40 mm trip threshold. At 40 ms, the same calculation gives 0.730 mm. The healthy-flow trial then tripped.

What the model found

Each comparison below uses the original buyer inlet. Volumes crossing after failure count immediately, even when oil is subsequently captured inside the installation.

Same flow, same unannounced loss

The broad cart admitted 21.409 L, the four strips with the original nozzle admitted 13.587 L, and adding the finite bellows gave 10.980 L. The finer time step gave 10.980 L. These are paired reference litres for the single tested onset.

Compact feed with its inlet elbow

A 0.32 m rotary port at the center of four sectors includes the elbow loss factor of 1.5 and the moving oil in the port. Paired crossing was 11.675647 L, or 11.675815 L on a finer time step. The seller bellows separately caught 2.718 hot L. The full-loss run credited zero genuine retention.

A restricted seller-side catch

With the bellows diversion delayed 40 ms, 13.423 L crossed. A bellows limited to 1 L per seller gave 11.332 L. A blocked branch returns the original-nozzle result of 13.587 L. Keeping the source at full rate until the seat closed gave 12.054 L.

Timing and false readings

Charging full forward flow through seat travel and each 5 L pressure pocket gave an upper bound of 26.67 L over 240 sampled full-loss start phases. When the physical follower itself moved as if the buyer were filling, 1,437.143 L crossed. A 1 mm slosh control also tripped a healthy cart.

A small hidden bypass

At 1% diversion, the trip took 2.481 s. Up to 375.31 L crossed in the conservative calculation, including up to 3.7531 L diverted. The rest reached the buyer in this partial-loss control.

Oil crossing both original inlets after failure



Paired reference litres in the same simulated total loss. All four bars begin at zero.

Installing the receiver

The 2.25 m straight runner needs 9.136 kPa additional pressure and is short by 7.175 kPa. That layout cannot inherit the successful delivery replay. Bringing four sectors together around a short rotary port keeps 0.182 kPa in the modeled pressure budget.

Narrow pressure margin

The central port has 0.25 m^2 flow area over 0.32 m. Restricting its aperture to 0.15 m^2 leaves a 0.701 kPa deficit. Measured bend losses, wet switching and available inlet pressure could consume the rated margin.

Partition support and trip accuracy

One missing tie in the straight cart demands 44.57 kN against 40.72 kN. The compact frame uses 70.1% of assumed tube capacity. If its 0.760 mm motion appears as equal follower error, one sign falsely trips a healthy cart. The other delays the trip to 92.25 ms and admits 19.175647 L. Staying within 0.10 mm requires rejecting at least 86.842% of that motion. This has not been demonstrated.

Exchange, energy and fill height

Peak modeled level is 3.052 m inside a 3.35 m cart. Including lifts and resets, 87.239 kWh is charged against 89.6 kWh. Overlapping under-deck reset and cart exchange takes 11.40 s in a 12.384 s dry window. Sequential operation takes 18.158 s and misses the window. The interlock enabling overlap still needs a loaded test.

Surface cleanliness and site release

The compact cart adds 92,198.4 m^2 across both fleets. At 2 µg/m^2 oil and 4 µg/m^2 moisture, the modeled paired trace charges are 0.999798307 L exterior oil and 0.698479976 L water in one hour. These totals assume bulk oil stays contained. The appearance of any exterior oil requires a separate measured pathway.

The filled rotor is additional inventory

Each reusable rotor contains 80 hot L. Both installed rotor charges together represent 152.381 reference L at risk if their seals fail. These existing charges are separate from new inlet crossing. A sealed rotor retains 0.814 reference m^3 source reserve per buyer. Dumping a rotor at each change produces a 18.615 m^3 deficit.

Physical acceptance test

Use a closed test loop with independent collection at the original buyer inlet and the site boundary. Repeat losses throughout a delivery stroke, recording genuine retained mass, follower error, pressure and seat leakage. Unevenly fill the sectors, obstruct the central port and require sequential exchange. These measurements determine whether the modeled transfer and flow limits hold in hardware.

The twenty registered incidents

With eight piston pairs down per train, minimum genuine paired flow was 400.156516 m³/h in the base system, 400.150773 m³/h in the strip replay and 400.150794 m³/h in the compact-hub replay. Across 175,680 required minutes, all 27,152 delivered portions met modeled quality limits. Both receiver replays require intact storage, successful switching and adequate inlet pressure. The long straight runner fails this pressure condition. The 40% target is 400 m³/h.

ID	Registered incident	Duty	Base[1]	Strip[1]	Hub[1]	Full case
01	Source closing energy lost and conventional valves jammed	0 h	—	—	—	Unverified
02	Terminal closing energy lost and conventional valves jammed	0 h	—	—	—	Unverified
03	Source and terminal closing energy lost with jammed conventional valves	0 h	—	—	—	Unverified
04	Trigger inlets blocked with jammed conventional valves	0 h	—	—	—	Unverified
05	Pilots blocked with jammed conventional valves	0 h	—	—	—	Unverified
06	Sleeves torn with jammed conventional valves	0 h	—	—	—	Unverified
07	Sleeve closing force tripled with jammed conventional valves	0 h	—	—	—	Unverified
08	5 mm² seat gaps with jammed conventional valves	0 h	—	—	—	Unverified
09	Three route boundaries lost	72 h	400.156516	400.150773	400.150794	Unverified
10	Independent heat envelope penetrated	72 h	400.156516	400.150773	400.150794	Unverified
11	Closed catch boundary lost	0 h	—	—	—	Unverified
12	Loaded collapse and outer-vault loss at 60 h	60 h	400.156516	400.150773	400.150794	Unverified
13	100 mm source-gas wall breach	72 h	400.156516	400.150773	400.150794	Unverified
14	Gas heat transfer degraded	72 h	400.156516	400.150773	400.150794	Unverified
15	Catch heat transfer reduced at 60 h	60 h	400.156516	400.150773	400.150794	Unverified
16	Local pocket outer boundary lost	72 h	400.156516	400.150773	400.150794	Unverified
17	Catch heat transfer lost at 60 h	60 h	400.156516	400.150773	400.150794	Unverified
18	Enclosure gas starts at 86 °C	60 h	400.156516	400.150773	400.150794	Unverified
19	Catcher shield fully open	60 h	400.156516	400.150773	400.150794	Unverified
20	All current quality evidence falsified	72 h	400.156516	400.150773	400.150794	Unverified

[1] Minimum genuine paired delivery in each required minute, in reference m³/h. A dash indicates that immediate isolation was required. Each incident requires containment to hour 72.

The private panel contains the buyer receiver test film, its experiment data and the full system study with case-by-case evidence. The full film runs 37:29.250. The buyer chapter begins at 36:24.500.

Buyer test film **Full system film** **Experiment data** **Full system panel**

The Haven Protocol

Emergency crude transfer and containment over 72 hours. The paired system combines movable buyer tanks, a dry drive, a shored catch beneath each loading yard and passive gas displacement.

400.157 m^3/h
Lowest genuine delivery in a due minute

3.175 m^3
Oil on one loading aisle at hour 72

0 / 20
Complete simulated missions qualified

Decision	Evidence on the shored-catch design
Can emergency service continue?	Six cases sustained 40% for 72 h. Five supplied oil to the required hour-60 shutdown. Nine isolated at onset. All twenty met their scheduled duties with eight pairs down per train. The minimum free-surface hot-water margin was 2.3937 kPa.
Where did the oil go?	After the loaded-yard loss at hour 60, each buyer's catch held 12,824.22 m^3 at hour 72. Oil remaining on the aisle fell from 636.92 to 3.1746 m^3. The legs held another 2.2619 m^3.
Can exterior oil stay below 1 L?	The conditional trace-oil total was 0.999570656 L. Just 0.429 mL remains for additional paired bulk escape. The installation lacks a verified exterior balance and site-specific structural proof.
What happens at a failed buyer?	With false weights, a physical follower limited the simulated mid-flow transfer to 34.53 L when it tracked true inventory. False follower movement admitted 1,437.14 L. Zero was observed when a mechanical interlock seated before separation.

Qualification

All twenty cases have an unresolved requirement. The added catch addresses oil remaining in the yard. The phase of the buyer failure, installed leakage and soil support still determine whether the entire system can meet its duty.

From the loading aisle to the cellar

A 3.75 m deep shored cellar, sixteen gravity legs and a closed variable-volume nitrogen holder serve each buyer. Each leg starts dry. Liquid from the aisle pushes its initial gas into a finite primer pouch.

Condition	Simulated outcome or qualification limit
Starting the drains	The 16 pouches and a movable gas holder provide a finite destination for displaced gas. At 84% usable floor and the upper drive ratio, the legs primed in 5.22 s without adding fresh water. Peak catch pressure was 111.090 kPa absolute.
Where the oil went	At hour 60 the loaded vehicles failed. Twelve hours later, each buyer had 12,824.217 m^3 in the catch, 2.262 m^3 in the gravity legs, 3.1746 m^3 on the aisle and 0.000 m^3 in damaged vehicles. Earlier open-slot drainage left 636.923 m^3 on the aisle for the same oil offer.
Residual film and floodwater	The last 3.1746 m^3 equals the model's 3 mm residual layer across the aisle. Real floor slope, low spots and wetting determine that depth. The catch held 1,531.366 m^3 of stormwater. The final oil and water discrepancies were below 0.0001 m^3.
If priming fails	Bleeding directly into the pressurized catch left 74.889 m^3 on the aisle. A 40 mm low spot left 42.328 m^3. A 0.15% flash-mass control left 4,964.1 m^3. the modeled level exceeds the assumed deck containment.

Loaded tanks
Released oil reaches aisle
→
Gravity legs
Resident liquid primes
→
Gas holder
Takes displaced gas
→
Cellar
Contains the liquid

Liquid and gas inventories are tracked separately. The gas holder changes volume during filling.

Pressure, foundations and flow

Both assignments of 73% and 100% gas access use the same twenty incident clocks with eight piston pairs unavailable per train. Ground preparation, gas charging and structures are included in the selected estimate.

Condition	Simulated outcome or qualification limit
Dry bearing seat	A 12 mm steel plate sits on a 6 mm shim. At 2 mm corrective machining, the seat reduces excavation by 2,896.7 m³ and ceramic by 9,024 tonnes. The new surface is charged to the contaminant budget.
Hot-water pressure	The minimum free-surface margin rose from 2.3156 to 2.3937 kPa, against 1.33 kPa required. At 2 kPa lower ambient pressure, cases 12, 18, 19 fall below the target and the minimum is 0.3937 kPa.
Flow and quality	Across 175,680 due minutes in the four settings, the minimum genuine flow was 400.156516 m³/h. All 27,152 sale portions met the modeled specification. Water reached 0.5687%, chloride 3.7853 mg/kg and sediment 0.02024%.
Excavation	The paired estimate is 72,191,791.0 m³, leaving 8,209.0 m³ to the cap. Using the 50% bulk construction allowance on the new vault depth gives 72,206,689.5 m³. Actual shoring, holder and pile connections still need a site load test.

What the exterior oil allowance covers

The one-litre limit applies to both trains together through hour 72. Oil on a loading aisle has a known location inside the model. Its eventual path across the site boundary requires separate evidence.

Condition	Simulated outcome or qualification limit
Gas purity and residue	At a bounded 0.65 ppbv gas charge, the conditional trace-oil total is 0.999570656 L. This leaves 0.429 mL for all bulk escape. Raw 5 ppbv gas takes the same layout to 1.00515036 L before bulk escape.
A continuous exterior path	With an assumed continuous 5 µm path per station, sustained differential pressure and the test viscosity, the paired leakage calculation adds 0.4374 mL. The modeled sum becomes 1.00000802 L. Installed leak paths and their true heads remain unmeasured.
Buyer water	Gas and surface charges total 0.698085544 L/h, leaving 0.914 mL/h for all additional paths. The normal prime uses storm liquid. Leakage from a wet path to the sale line can consume this margin.
Automatic shutdown	A mechanically compelled disconnect seated before failure admitted zero. In the separate unexpected-loss test the dock latch admitted at most 34.53 L when both weights read healthy. False physical follower travel admitted 1,437.14 L.

Testing the remaining site margin

The two buyers share one exterior allowance. The timed leakage calculation follows the loaded carts from hour zero, then follows liquid pressure in the aisle and catch through hour 72. It assumes specified pore lengths, viscosity and geometry.

Condition	Simulated outcome or qualification limit
Floor and aisle pathways	At 2 mPa·s, the paired model with a 10 µm through-path at each aisle and each catch floor totals 0.999946739 L, with hot leak volume charged in full. Peak catch-floor pressure was 31.085 kPa above the exterior. The upper-bound time calculation used 12,163 steps.
An additional damaged cart	One additional direct path of the same size from a loaded cart at each buyer changes the total to 1.001677924 L. Neither assumed route count establishes the true number of simultaneous leaks.
Purifying the purchased gas	The linear sorption model gives 0.598 ppbv including assay uncertainty. Two 472.5 kg beds with a finite 350 mg/kg saturation capacity and an assumed uptake coefficient of 0.01/s give 0.618 ppbv. Over seven days the solid captures 5.104 g. The installed supply specification is 0.65 ppbv.
An exhausted or weaker bed	At 80 mg/kg the predicted gas upper limit reaches 0.696 ppbv and exceeds the purchase specification. Fully exhausted media increase the paired trace charge to 1.00534277 L. Real sorbent capacity, uptake and shipping cleanliness require measurement.
Supporting the loading aisle	The 900 mm girder reaches 148.10 MPa against a 160 MPa screen. A 750 mm girder reaches 186.67 MPa. The holder and its conduits require 1,922 m^2 of additional land. Actual pile capacities and connections remain unknown.

Shored-catch incidents 01–10

Each row refers to the incident in its own operating schedule. A case owes either 72 hours of service, 60 hours followed by a stop, or immediate isolation. Every case owes safe containment through hour 72.

Incident	Duty	Genuine m³/h	Water kPa	Loaded balance	Full case
01. Source closing energy lost and conventional valves jammed	Stop	—	4.160	—	Unverified
02. Terminal closing energy lost and conventional valves jammed	Stop	—	4.160	—	Unverified
03. Source and terminal closing energy lost with jammed conventional valves	Stop	—	4.160	—	Unverified
04. Trigger inlets blocked with jammed conventional valves	Stop	—	4.160	—	Unverified
05. Pilots blocked with jammed conventional valves	Stop	—	4.160	—	Unverified
06. Sleeves torn with jammed conventional valves	Stop	—	4.160	—	Unverified
07. Sleeve closing force tripled with jammed conventional valves	Stop	—	4.160	—	Unverified
08. 5 mm² seat gaps with jammed conventional valves	Stop	—	4.160	—	Unverified
09. Three route boundaries lost	72 h	400.157	4.160	—	Unverified
10. Independent heat envelope penetrated	72 h	400.157	4.160	—	Unverified

Reading the result

Cases 12, 18 and 19 include a loaded-catcher collapse. A closed internal mass balance gives no credit for oil subsequently escaping to the exterior. Open supports and exterior retention apply to all twenty. The private panel lists every case decision.

Shored-catch incidents 11–20

Each row refers to the incident in its own operating schedule. A case owes either 72 hours of service, 60 hours followed by a stop, or immediate isolation. Every case owes safe containment through hour 72.

Incident	Duty	Genuine m^3/h	Water kPa	Loaded balance	Full case
11. Closed catch boundary lost	Stop	—	4.160	—	Unverified
12. Loaded collapse and outer-vault loss at 60 h	60 h	400.157	2.410	Checked	Unverified
13. 100 mm source-gas wall breach	72 h	400.157	4.160	—	Unverified
14. Gas heat transfer degraded	72 h	400.157	4.240	—	Unverified
15. Catch heat transfer reduced at 60 h	60 h	400.157	4.160	—	Unverified
16. Local pocket outer boundary lost	72 h	400.157	4.160	—	Unverified
17. Catch heat transfer lost at 60 h	60 h	400.157	4.160	—	Unverified
18. Enclosure gas starts at 86°C	60 h	400.157	2.394	Checked	Unverified
19. Catcher shield fully open	60 h	400.157	2.411	Checked	Unverified
20. All current quality evidence falsified	72 h	400.157	4.240	—	Unverified

Reading the result

Cases 12, 18 and 19 include a loaded-catcher collapse. A closed internal mass balance gives no credit for oil subsequently escaping to the exterior. Open supports and exterior retention apply to all twenty. The private panel lists every case decision.

The Haven Protocol buyer inlet

Emergency crude transfer and containment after damage. The design target is to deliver 40% of normal flow for 72 hours to an intact buyer and stop delivery to a failed buyer while containing the oil already on site.

400.159 m^3/h
Lowest required minute of genuine delivery

1.437 m^3
Crossed the failed buyer with final observations replayed

0 / 20
Complete simulated missions qualified

Operating condition	Outcome
Recoverable damage	Six incidents delivered for 72 hours. Five delivered to hour 60 before isolation. Nine isolated at onset. Eight piston pairs per train were unavailable. All 27,152 modeled sale portions met the specified grade limits.
Buyer fails during flow	Both weights read healthy. The independent tank-level trip admitted 117.19 L. In a separate bench calculation a direct mechanical comparison limited transfer to 34.53 L. A mechanically compelled disconnect seated before loss admitted zero.
Concealed diversion	With all final observations replayed, 1,437.14 L entered the failed buyer and it retained zero. If the mechanical follower also travels falsely, its stop cannot distinguish this loss.
Total-loss containment	The roof and mobile layout meets the trace-oil allowance only if all bulk oil stays inside. A common loss across the loaded yard left 636.9 m^3 on the aisle at hour 72. Its eventual exterior release is unknown.

Decision

The transfer and grade tests support limited service on the defined recoverable schedules. The unannounced buyer diversion and the unverified final destination of spilled oil prevent qualification. All numerical results are simulations.

What stops a failed buyer

The acceptance boundary is the original buyer inlet. Oil crossing after loss counts even if a downstream structure catches it. Volumes below are reference litres across both buyers.

Condition	Measured or calculated result
Physical separation	The interlocked selector closed 38.43 ms before an intact disconnect opened. Zero crossed. At faster travel, the valve seated after loss and 5.94 L crossed. An internal break with no warning admitted 1,442.86 L.
Weights remain falsely healthy	The receiving level, independent of the weights, stopped the mobile-tank transfer after 117.19 L crossed. The shutoff remains valuable even though this misses the zero-transfer requirement.
Indistinguishable receivers	Two simulated buyers produced the same 18,021 observed records and commands. One retained 1,437.14 L. The other retained zero. The controller kept sending oil across the same boundary.
Why response time matters	At 400 m^3/h, some 100 ms interval carries at least 11.11 L. The modeled pulse reached 14.29 L. An undetectable failure during that interval defeats an exact-zero reactive shutoff.

A mechanical trip independent of weight

A dock-mounted differential compares a shaft driven by actual inlet displacement with a follower on the liquid surface of the final tank. A magnetic pickup through a sealed wall transmits the follower motion to a spring latch. If delivered oil gets ahead of retained oil, the latch removes the inlet valve hold-open force. Weights and digital indications have no mechanical authority.

Condition	Measured or calculated result
Full diversion with false weights	The final tank stopped gaining oil. At the flowing test instant, at most 34.53 reference L crossed both inlets, including both 5 L pressure pockets. The bound over 240 sampled start phases reached 34.57 L. No post-loss volume was credited to delivery.
Assumed mechanical performance	The liquid surface covers 20.25 m^2. The assumed latch gap is 0.25 mm, residual position error is at most 0.10 mm, follower lag is 15 ms and the spring valve seats in 80 ms. Flow is charged through the full travel. Stable tracking at these tolerances has not been demonstrated.
Controls that defeat the device	A falsely moving physical follower admitted 1,437.14 L. A 1 mm adverse position error tripped a healthy tank. At 160 ms seating, the full-diversion bound became 45.95 L. A small diversion can escape the deadband.
Qualification boundary	The comparison senses the final tank and preserves the original buyer inlet. The float, magnetic coupling, dock reset, calibration, trapped gas and pressure-pocket leakage need a loaded rig test. The bench device has no full-mission, energy or exterior-oil credit.

Inlet meter
Turns with incoming oil
→
Tank follower
Moves with retained liquid
→
Differential
Trips on excess inlet travel
→
Spring valve
Closes the original inlet

A separate shaft carries the final-tank observation to the dock latch. A freely moving false follower can defeat this comparison.

Three days on finite stock

A fixed dry drive ratio of 1.00510 meters customer-quality stock through three alternating cylinders. Two independent buyers receive the combined flow. Each pressure rule was tested with 73% gas access on either train and 100% on the other.

Condition	Measured or calculated result
Actual sale	175,680 required paired minutes were replayed across four operating settings. The lowest genuine minute was 400.158531 m³/h. The stock calculation includes the dock debit. 1.207 m³ remained per buyer.
Buyer quality	Water peaked at 0.5684% by volume, organic chloride at 3.2861 mg/kg and sediment at 0.02019% by mass. Limits are 1%, 5 mg/kg and 0.05%. The calculation charges surface residues and fresh gas.
Power and motion	Each buyer required up to 29.401 kW and 7.368 GJ. The yard model had zero late tank preparations. Full independent power loss and mechanically damaged returns remain separate failure tests.
A faster drive	At a ratio of 1.00545, indicated service reached 400.299 m³/h, but each buyer exhausted the original stock by 3.899 m³. This setting fails.

Margins on the same installation

The 12 mm support plate, movable receivers and two pipe lengths are charged to one material and fluid budget. Each train carries eight unavailable piston pairs. Only the modeled layouts and pressure rules receive credit.

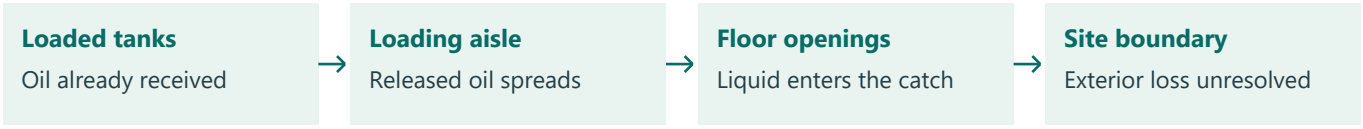
Condition	Measured or calculated result
Hot water	The least hot-water pressure above saturation was 2.3156 kPa against the 1.33 kPa requirement. A larger bedding movement or lower ambient pressure can consume that margin.
Service measurement	With a further 0.020% scale error and a 3 ms error at either end of an arbitrarily phased minute, the lower bound remains above 400 m³/h. At 5 ms it falls below 400. These clock and scale errors are sensitivity inputs.
Cut-to-length gas pipes	Each buyer uses two groups of 18 pipes, at 37.9 and 37.2 m. Nominal roof pressure including the raised rack is 171.2915 kPa absolute. At the short tolerance it approaches 171.306 kPa against a 171.325 kPa limit. Concentrating the same oil on 42% of the pool floor wets roof openings earlier and raises pressure above 193 kPa.
Civil works and trace oil	Paired excavation is 72,151,681.8 m³ against 72,200,000. Water ingress is 0.669666 L/h. The conditional exterior charge is 0.999979743 L against 1 L, leaving 20.26 microlitres. This assumes zero additional bulk escape.

Measurement uncertainty and conformity assessment · BIPM JCGM 106

Where the oil goes after a common loss

Closing the dock isolates the parked vehicles from further supply. A common failure can still breach the oil they already contain. A separate whole-yard catch was tested with heat, displaced gas and finite return passages.

Condition	Measured or calculated result
Stored stock at hour 60	At the nominal drive ratio, 12,829.399 m³ hot oil was present per buyer. Only 46.328 m³ was in the connected tank. Damage across parked tanks exposes a much larger inventory.
Liquid on the aisle	At the upper drive tolerance, with all 212 returns available, peak catch pressure was 111.760 kPa absolute. The model still held 636.923 m³ of oil on the aisle at hour 72. Neither the aisle nor a damaged vehicle is a verified exterior boundary.
Common loss with restricted gas	Blocking all return passages traps oil in vacuum-limited ruptured vehicles. Additional flash gas can leave over 6,200 m³ on the aisle. A lower catch pressure or smaller floor inventory alone cannot qualify final containment.
Fully charged catch option	Charging the catch and its headers gives 1.00362565 L of trace oil, above 1 L before bulk escape. It needs 72,199,902.8 m³ of excavation before gantry and footing costs. The combined margin cannot be credited by using the roof-only budget.



The hour-72 ledger accounts separately for oil remaining in damaged tanks, on the aisle and in the catch.

Combined incident results 01–10

The minimum flow is genuine oil received across both buyers in a required minute. Both assignments of 73% and 100% gas access are included. A dash indicates that delivery was never due.

Incident	Sale h	Genuine m³/h	Water kPa	Gas °C	Full case
01. Source closing energy lost and conventional valves jammed	0	—	4.149	115.83	Open
02. Terminal closing energy lost and conventional valves jammed	0	—	4.149	115.83	Open
03. Source and terminal closing energy lost with jammed conventional valves	0	—	4.149	115.83	Open
04. Trigger inlets blocked with jammed conventional valves	0	—	4.149	115.83	Open
05. Pilots blocked with jammed conventional valves	0	—	4.149	115.83	Open
06. Sleeves torn with jammed conventional valves	0	—	4.149	115.83	Open
07. Sleeve closing force tripled with jammed conventional valves	0	—	4.149	115.83	Open
08. 5 mm² seat gaps with jammed conventional valves	0	—	4.149	115.83	Open
09. Three route boundaries lost	72	400.159	4.149	115.83	Open
10. Independent heat envelope penetrated	72	400.159	4.149	115.83	Open

Acceptance

Six cases owe 72 hours, five owe 60 hours before isolation and nine owe immediate isolation. The sudden buyer failure is a separate test of a shared protective function.

Combined incident results 11–20

The minimum flow is genuine oil received across both buyers in a required minute. Both assignments of 73% and 100% gas access are included. A dash indicates that delivery was never due.

Incident	Sale h	Genuine m³/h	Water kPa	Gas °C	Full case
11. Closed catch boundary lost	0	—	4.149	115.83	Open
12. Loaded collapse and outer-vault loss at 60 h	60	400.159	2.333	115.83	Open
13. 100 mm source-gas wall breach	72	400.159	4.149	115.83	Open
14. Gas heat transfer degraded	72	400.159	4.229	116.07	Open
15. Catch heat transfer reduced at 60 h	60	400.159	4.149	115.83	Open
16. Local pocket outer boundary lost	72	400.159	4.149	115.83	Open
17. Catch heat transfer lost at 60 h	60	400.159	4.149	115.83	Open
18. Enclosure gas starts at 86°C	60	400.159	2.316	115.83	Open
19. Catcher shield fully open	60	400.159	2.333	115.83	Open
20. All current quality evidence falsified	72	400.159	4.229	116.07	Open

Acceptance

Six cases owe 72 hours, five owe 60 hours before isolation and nine owe immediate isolation. The sudden buyer failure is a separate test of a shared protective function.

Operating envelope comparison

Hot-water backing and buyer equipment are compared on the same defined incident schedule. The following comparison uses stationary buyer cylinders and specifies each equipment configuration.

2.316 kPa
Hot-water pressure above saturation

400.044 m^3/h
Lowest required minute of genuine oil delivery

0 / 20
Complete simulated missions

Operating question	What the end-to-end study established
Is there enough gas and pressure?	With 73% of gas access on either train and 100% on the other, eight piston pairs unavailable per train and matched hot-water duty, a 12 mm bearing plate raises the limiting pressure margin from 1.341 to 2.316 kPa. The requirement is 1.330 kPa.
Can the surviving line deliver?	The bearing-plate and three-cylinder installation met all 175,680 required paired minutes. All 27,152 sale portions met grade. Counted excavation is 72,130,333 m^3 against 72,200,000 m^3. Exterior oil is 0.999802 L under the specified cleanliness and containment assumptions.
What happens when the buyer fails?	A separate movable receiving tank measures oil actually retained. With false weights and the inlet meter still turning, 117.19 reference L crossed after loss. With the final tank level also falsely healthy, 1,437.14 L crossed. Genuine receipt was zero.
Do total losses stay contained?	A two-dimensional corner release sent 54.34 m^3 of oil over the inner curb before first perimeter roof contact. Initial gas-passage availability changed the pressure verdict. Where all spilled oil ends up at hour 72 is unresolved.

Engineering decision

Zero complete missions qualified. Hot-water performance and reduced delivery met their scheduled tests on the bearing-plate design. Unseen buyer loss, combined contamination, roof contact and site response prevent an end-to-end pass. All results are simulations.

A bearing plate keeps pressure above the hot-water limit

The pipe grid bears directly on 12 mm steel plates and solid shims. The model charges their weight, added resistance, surfaces and excavation. The original buyer and roof remain in this matched test.

Condition	Simulated outcome
Hot water and repeated duty	With a 0.2°C hotter water film and 25 mm relative rise, minimum free-surface pressure above saturation increases from 1.341 to 2.316 kPa. The requirement is 1.330 kPa. Both 73%/100% assignments and both pressure rules were replayed with eight pairs down per train.
Conditions that change the outcome	A 0.5°C hotter film and 40 mm rise gave 1.393 kPa. With ambient pressure 2 kPa lower the margin fell to 0.316 kPa. A 100 mm bedding gap gave 0.179 kPa. Cases 12, 18 and 19 fail with lower ambient pressure and with the wider bedding gap. The 0.5°C and 40 mm trial passes all 20.
Construction and cleanliness	The design uses 52,475 t steel and 18,049 t of shims. Paired excavation is 72,130,333 m^3. At 0.10 µg/m^2 new surface residue, rated exterior oil is 0.999802 L. At ten times that residue it is 1.002307 L.
Buyer flow and quality	The 691,200 train-minute input replay gives 400.044194 m^3/h at the limiting required minute. All 175,680 required paired minutes and 27,152 sale portions met their scheduled tests. The worst rolling-hour water ingress is 0.665048 L. Seat and foundation behavior still require installed tests.

Gas access on either train

The 5.5 m gallery supplies the remote circulation equipment. A restricted train has 919 available parcels out of 1,262. The local held-gas volume is one quarter of its assigned capacity.

Condition	Simulated outcome
Swapping the restriction	The registered run covered 20 cases, both trains and both 73%/100% assignments. Each assignment passed 40 of 40 train-case states. The highest gallery gas temperature was 116.067°C against 120°C. The local pipe-face gas temperature uses a separate model.
Stored work	Available drive work was 1,327.82 GJ against 1,182.86 GJ including reserve. A longer modeled governor delay passed the temperature gate.
Failed controls	Starting with a hot gallery lining reached 125.791°C. A seized circulation shaft reached 193.649°C. Both controls failed all 80 train-case states.
Operating evidence	The same signed case and duty identify the delivery run. The flow is genuine hydrocarbon delivered as a full-minute average. Six cases require 72 h of sale, five require 60 h followed by isolation, and nine require immediate isolation. Every case owes 72 h of containment.

Measuring oil in the final buyer tank

A tank parks beside the buyer inlet, fills at a short dock, seals and moves to a parking bay. A dry follower measures the rise of oil in the tank. All delivered product remains on site through hour 72.

Condition	Simulated outcome
Signal beyond the diversion	At second 20 the true inlet was passing oil, both weights falsely indicated receipt and the collector stayed dry. The tank level stayed flat. The follower stopped the transfer after 117.19 reference L had crossed the original paired inlets. With falsely increasing tank level, 1,437.14 L crossed. Genuine receipt after total diversion was zero.
Reference and alternative	Fixed receiving cells registered 93.62 L in the same fault, but their long liquid distribution header exceeded the transient pressure allowance. The movable tank removes that header. Its calculated pressure margin is 1.970 kPa. Slower indication can admit additional oil.
Yard and service	The yard holds 256 tanks per buyer. The model uses 6,242.2 m^2 per buyer, 72,134,302 m^3 paired excavation and 400.038130 m^3/h minimum genuine flow on its own duty. Slowed yard travel can miss a required preparation. A parked tank rupture remains a separate containment case.
Shared resource conflict	The mobile receiver alone projects 0.999949 L exterior oil at 0.001 ppmw condensables in its fresh gas and 0.1 µL escaping per disconnect. Adding the bearing plate surfaces raises this to 1.000227 L. That exceeds the one-litre limit before adding an independent catch.

A corner release can reach the roof

Cases 12, 18 and 19 each stop delivery at hour 60. The stock histories give about 12,826 m^3 of hot buyer oil per station. The incident model adds 1,531 m^3 of intercepted water with the drains blocked.

Condition	Simulated outcome
The same inventory in a different place	On the 140 by 140 grid the 65% straight-front test sent zero oil over the 6.8 m inner curb. With the initial pool in a corner, 54.34 m^3 crossed before the first perimeter roof-contact interval. At 55% initial corner coverage, 197.75 m^3 crossed before that interval.
Limit of the liquid calculation	In the 65% corner the model gives 66.43 m^3 by second 20 if the surface can keep moving freely. The true roof can change pressure, splash and collection. The 40% corner starts above the roof and cannot represent a dry, intact roof at startup.
A test of the actual closure time	A 45% corner pool first wets one inlet at 1.526 s. The independent two-branch calculation keeps all trapped gas. With 12 pre-existing outages the pressure reaches 170.472 kPa when that thirteenth branch jams on contact, under the 171.325 kPa ceiling. If already shut at the start it reaches 172.404 kPa and fails.
What the numbers measure	Crossing the inner curb moves oil to another part of the installation. Reaching the atmosphere requires another open path. The first gas pulse spans three seconds. a second outage, two-phase ingestion, roof reactions and continued leakage require their own evidence.

Secondary containment and liquid overtopping · UK HSE

Where the oil can go with every drain closed

Two independent covered perimeter catches were tested with the measured times, wall locations and volumes of liquid leaving the simulated inner curb. Both layouts use fixed storage. No pumping or drainage was credited.

Condition	Simulated outcome
Raised trough	A 4 m wide trench-shaped trough raised to the inner crest holds 1,243 m^3 per buyer below its assigned operating level. In the 55% corner trial the caught liquid stayed below the sill, but the horizontal sheet estimate exceeded 4 m. The trough can miss the oil even with space remaining.
Recessed ring	A 12 m wide catch with 8.8 m from floor to inlet gives 25,726 m^3 per buyer, exceeding the entire modeled buyer and storm inventory. At the specified three gas charges its rolling-hour water is 0.702890 L and exterior trace oil is 1.005131 L. Both exceed their limits.
Whole installation	Adding the deep catch, mobile receiver and plate together would give 72,202,588 m^3 of counted excavation before site-specific changes. The ceiling is 72,200,000 m^3. These component calculations cannot qualify the combined installation.
The 72-hour check	Early curb flow and final static storage leave open whether all oil enters the catch, the roof can accept the displaced gas, and the barrier remains liquid-tight. The simulation archive includes local water levels, overshoot, blocked corners, numerical volume balances and the later gravity-only spill allowance.

Operating cases 01–10

Each case includes both gas-access assignments. The water figure is the smallest free-surface margin at the hotter film and 25 mm movement. The gas figure is the highest gallery temperature across the two trains. An immediate-isolation case owes no sale.

Incident	Sale h	Genuine m³/h	Water kPa	Gas °C	Full case
01. Source closing energy lost and conventional valves jammed	0	—	4.149	115.83	Open
02. Terminal closing energy lost and conventional valves jammed	0	—	4.149	115.83	Open
03. Source and terminal closing energy lost with jammed conventional valves	0	—	4.149	115.83	Open
04. Trigger inlets blocked with jammed conventional valves	0	—	4.149	115.83	Open
05. Pilots blocked with jammed conventional valves	0	—	4.149	115.83	Open
06. Sleeves torn with jammed conventional valves	0	—	4.149	115.83	Open
07. Sleeve closing force tripled with jammed conventional valves	0	—	4.149	115.83	Open
08. 5 mm² seat gaps with jammed conventional valves	0	—	4.149	115.83	Open
09. Three route boundaries lost	72	400.044	4.149	115.83	Open
10. Independent heat envelope penetrated	72	400.044	4.149	115.83	Open

How to read the register

The thermal and minute-flow results use the same source and buyer duty. The loaded receiver trials use the hour-60 oil for cases 12, 18 and 19. Other physical and site gates remain open in all twenty cases.

Operating cases 11–20

Each case includes both gas-access assignments. The water figure is the smallest free-surface margin at the hotter film and 25 mm movement. The gas figure is the highest gallery temperature across the two trains. An immediate-isolation case owes no sale.

Incident	Sale h	Genuine m³/h	Water kPa	Gas °C	Full case
11. Closed catch boundary lost	0	—	4.149	115.83	Open
12. Loaded collapse and outer-vault loss at 60 h	60	400.044	2.333	115.83	Open
13. 100 mm source-gas wall breach	72	400.044	4.149	115.83	Open
14. Gas heat transfer degraded	72	400.044	4.229	116.07	Open
15. Catch heat transfer reduced at 60 h	60	400.044	4.149	115.83	Open
16. Local pocket outer boundary lost	72	400.044	4.149	115.83	Open
17. Catch heat transfer lost at 60 h	60	400.044	4.149	115.83	Open
18. Enclosure gas starts at 86°C	60	400.044	2.316	115.83	Open
19. Catcher shield fully open	60	400.044	2.333	115.83	Open
20. All current quality evidence falsified	72	400.044	4.229	116.07	Open

How to read the register

The thermal and minute-flow results use the same source and buyer duty. The loaded receiver trials use the hour-60 oil for cases 12, 18 and 19. Other physical and site gates remain open in all twenty cases.

The buyer inlet during a hidden loss

The three-cylinder receiver establishes the effect of displacement checks and an independent spill flap at the original buyer inlet. This installation uses the original pipe backing.

12.91 L
Late oil when buyer displacement stops

400.044 m^3/h
Lowest genuine delivery in a required minute

0 / 20
Complete simulated missions

Requirement	Result for the three-cylinder receiver
Failure during flow	At second 20, both inlets pass 75 hot L/s and both weights stay falsely healthy. The collar alone admits 1.443 m^3. The three-cylinder system admits 12.91 reference L if the receiving meter stops, or 27.77 L if diverted oil still drives the meter but reaches the spill plate.
Hidden loss	If the diverted oil drives the meter and misses the plate, 1,437 L (1.437143 m^3) crosses the failed buyer inlet. With sustained drive, 6.786 m^3 crosses in the one-minute test. Genuine receipt after failure is zero.
Service and quality	Eight piston pairs are unavailable per train. The minimum is 400.044 m^3/h across 175,680 due minutes in four settings. All 27,152 modeled portions meet grade. Six cases require 72 h flow, five require 60 h then isolation, and nine require immediate isolation.
Water, exterior oil and earthworks	Paired water ingress is 0.665048 L/h. Rated exterior oil is 0.999523 L if the bulk spill stays contained. Site excavation is 72,112,952 m^3. Higher surface residue exceeds the one-litre oil limit.

Engineering decision

0 of 20 meet every modeled requirement. A passing delivery schedule alone cannot establish safe isolation. The assumed spill collection, loaded receiver response and site support still require verification. No physical installation was tested.

Three small cylinders keep the buyer inlet supplied

Each buyer has three finite 35 L seller cylinders. One empties, a second takes over as the first slows, and the third refills. Their flow overlaps for 120 ms. The gas buffer and pump stay at the original 10 m supply rise.

Test or component	Result on the combined installation
Permission to deliver	Two physical authorizations limit how many seller strokes can be outstanding. A receipt must come from the buyer-side displacement meter before a third stroke begins. The 200 ms rolling comparison can trip the common valve earlier. A separate spill flap can trip that same valve if oil is lost beyond the meter. Neither channel uses the buyer's weight.
Service across the named cases	With eight piston pairs down per train, the lowest genuine full-minute rate was 400.044211 m^3/h. All 175,680 required paired minutes across four settings passed. Six cases owe 72 hours of sale, five owe 60 hours and nine owe immediate isolation. A minute with the smallest margin has room for only 0.737 L of additional paired shortfall.
A repeatable stop	The programmed seat lead is 20 ms before the minute reset, with ±5 ms allowed. Stored oil stays behind blanked outlets. A new minute needs fresh displacement and current permission. The system reserves 3.4 hot L per buyer at startup. If the seat closes after the reset, some oil can enter a failed receiver.
Commercial load	Each of the three cylinders at each buyer undergoes about 146,880 cycles over a full 72 h service duty. The evidence includes refill and valve timing. Seal endurance, seating under pressure and installed performance remain untested.

Seller cylinders
Overlap the strokes
→
Buyer inlet
Count every crossing
→
Buyer meter
Check displacement
→
Receiving tank
Verify actual receipt

The separate chute trips the buyer inlet when diverted oil reaches its plate. Failure upstream or downstream of the meter produces different evidence.

How much oil crosses with falsely healthy weights?

The simulated loss starts while both buyer inlets are flowing at 75 hot L/s. Falling weight contributes no useful signal. The same 10 m installation, cylinder timing and original buyer boundary apply to each of the following locally observable and hidden losses.

Test or component	Result on the combined installation
Diversion before the receiving pickup	The meter stops advancing and the common valve starts closing after 35 ms. The ideal crossing is 10.71 reference L. With the modeled trapped liquid and pipe response, 12.91 L crosses. All of it is counted as failed-buyer transfer.
Diversion after the pickup	The scale still reads healthy and the real inlet meter keeps moving. When the spill reaches the independent flap, the linkage trips after 0.135 s. Including the same hydraulic closing response, 27.77 reference L crosses before isolation.
Hidden internal path	A downstream diversion that also leaves the spill flap dry admits 1.437143 reference m^3 through residual drive and closure. A continuing drive admitted 6.786017 m^3 in a separate one-minute test. A motion signal can be truthful while actual receipt is zero.
Jammed common seat	When the buyer pickup stopped but the closing seat jammed, outstanding strokes admitted 117.23 reference L in the displacement test. Permitting a third unchecked stroke raised this to 183.76 L. Stored oil in connected branches has a separate release allowance.

Emergency isolation and valve closure considerations · UK HSE HSG244

Product, excavation and exterior oil on the same layout

The resource account includes the 6.8 m curb, overhead gas paths, local gas buffers, two cylinder pads and separate dry spill links. The new machine and receiver pickup assume a mobile surface residue of 0.1 mg/m². Post-failure escape of the bulk liquid remains a separate requirement.

Test or component	Result on the combined installation
Delivered product	Across 27,152 sale portions, 0 exceeded the modeled limits. The worst results were 0.6180% water, 3.4937 mg/kg chloride and 0.02031% solids. Both trains together admit 0.665048 L in the worst rolling hour against 0.699 L.
Both trains through hour 72	Conditional exterior oil totals 0.999523 L, leaving 0.477 mL for all further escape. Raising residue on the new machine and buyer pickup to 10 mg/m² gives 1.000257 L. Letting even one percent of the intercepted downstream late transfer reach outdoors adds 0.292 L.
Site and equipment	Counted excavation is 72,112,952.4 m³ against 72,200,000. It includes an additional 57.6 m³ of machine pads. The buyer pickup fits on the assumed existing support. Additional surveyed foundations, if required, need a separate debit.
What remains open	A sudden loss while accepting oil gives a finite transfer before the shutoff responds. An unobserved downstream path, a leaking seat, new foundation movement or loss of the independent roof can defeat containment. A complete 72-hour end-to-end pass has not been demonstrated for any of the twenty cases.

Pressure and power at the original lift

The three-cylinder arrangement retains the original 10 m rise. A cold gas charge and the resistance of the buyer displacement meter both affect the pressure available to push oil into the receiving equipment.

Test or component	Result on the combined installation
Buffer and buyer pressure	At 156 kPa absolute cold fill, the minimum computed pressure above the maximum buyer load is 2.054 kPa. The assumed production unit combines the wet regulator and receiving measurement into one restriction.
Work for 72 hours	The required healthy schedule uses 7.3525 GJ per buyer of 7.4052 GJ available. Peak continuous pump and charge draw is 29.335 kW against 30 kW. A permanent peak load has a different energy demand.
Fill tolerance	Cold settings from 155.5 to 156.5 kPa meet the scheduled work, power and pressure checks. At 158 kPa the scheduled work rises to 7.4121 GJ and exceeds the allowance. A hot sealed charge also fails the registered upper-pressure study.
Qualification under load	A rig must measure refill, the overlap between strokes, seat closure under pressure and the pressure drop across the complete receiving assembly on a common clock. The simulation assumes separate positive displacement and a finite amount of trapped oil.

250 L cylinder and chute comparison

At second 20, oil is already crossing both original buyer inlets. Both scales report normal receipt after failure. The model measures all new crossing from the instant of loss, including oil that moves while the protection is responding.

Test or component	Result on the combined installation
Two independent observations	A finite seller cylinder must finish its stroke and earn a new transfer from actual receiving displacement. A second, dry linkage trips from liquid entering the protected spill chute. Oil reached the failed buyer even if it was subsequently captured.
Matched flow and cutoff	The 250 L cylinders deliver 80 hot L/s per buyer immediately before loss. When diverted oil still moved the buyer inlet meter but reached each spill flap, 27.28 reference L crossed after loss. Holding full flow until both seats closed instead gives 33.37 L in the same test.
Hidden downstream leak	If both scale and inlet displacement remained credible and the oil bypassed the spill chutes, 1.478095 m^3 crossed before the residual motion ended. The original collar under its own 75 L/s waveform admitted 1.442857 m^3. Healthy-looking instrumentation cannot distinguish these two physical paths before their signals diverge.
Time and location of measurement	The inlet meter measures what crosses its own location. A rupture downstream can leave that measurement correct while genuine delivery is zero. The protected chute detects only oil that actually reaches it. A retained bulk inventory and a stable weighing frame provide different information.

What can deliver zero after loss?

A moving route selector can warn the buyer inlet while its receiving path is still intact. A sudden internal rupture can occur with the selector stationary and the inlet already passing oil. The original buyer boundary stays in the same place in every comparison.

Test or component	Result on the combined installation
A genuine advance signal	With 20 mm of intact sealing travel and a 0.20 m/s change, the valve seated before the route separated. New oil after loss was 0.000000 m^3. At 1 m/s, 5.938 L crossed. Without advance motion the same selector permits the whole ten-second tail.
A finite 35 L piston	With false weight and the independent receiver motion actually stopped, the rigid-line result was 4.848 L. Including a compliant 5 L local oil volume per buyer raised the result to 8.610 L. The hard stop alone cannot remove stored fluid momentum.
Why a different fault gives a different answer	During any interval when the healthy and failed receivers produce the same physical inputs, a controller in the same starting state gives the same output. Positive inlet flow over that interval transfers a positive volume into either receiver. False weight removes one possible distinction. A downstream diversion can remove the inlet-motion distinction too.
Commercial decision	A rig can establish a credible maximum late volume by recording true failure, inlet flow, seat position, caught oil and pressure on one clock. The evidence supports a bounded-release research prototype. It does not establish zero transfer for a sudden loss at an already-flowing inlet.

Which receiving equipment can sustain 40% flow?

Each seller cylinder both fills and empties through separate ports. The cycle pays for opening, closure, handoff and the next charge. The coupled hydraulic calculation checks local pressure, peak drive, stored energy and the volume available at each minute boundary.

Test or component	Result on the combined installation
35 L with serial handoffs	With a full start and stop for every stroke, 75 hot L/s peak and a 20 ms handoff, the best gross paired rate is 325.868 m^3/h. This misses 400 before any water or other delivery losses. The smaller after-loss figure for this arrangement cannot qualify service.
250 L working option	At 80 hot L/s peak, a 20 ms handoff, 156 kPa initial buffer pressure and 8 m lift, the modeled due-minute minimum is 400.203 m^3/h. Each buyer requires 27.437 kW and 7.123 GJ. The calculated pressure head remaining is 1.949 kPa.
Slower proof	Lengthening the 250 L cylinder handoff to 250 ms limits gross delivery to 394.862 m^3/h. A larger permitted dose can help throughput but increases the inventory outstanding when the receiver stops acknowledging.
Operating exposure	Six named cases owe 72 hours of delivery, five owe 60 hours followed by isolation and nine owe immediate isolation. Every case owes 72 hours of containment. The flow figures are full-minute averages. The 20 scheduled controller results and the zero-crossing mid-flow challenge are distinct tests.

How the spill trip responds to false weights

A collector-mounted plate deflects under the momentum of diverted liquid. It releases a local shutoff without using buyer weight or software. The model includes flight time across the chute, spring and damper response, linkage travel and the valve's flow curve.

Test or component	Result on the combined installation
Transport delay	On the original 75 L/s waveform, full capture trips the linkage in 0.135 s and admits 25.57 L. An extra second before oil reaches the flap raises this to 168.43 L.
Partial capture and nuisance trips	At 10% capture, the original 1.443 m³ crosses. In a separate healthy case, a 20 L/s water stream triggered the plate and interrupted valid service. The plate responds to force and requires a reliably segregated spill route.
Oil outside the plant	Every litre crossing the buyer is counted against isolation. Its exterior fate depends on the guard. On the original waveform, letting one thousandth of the diverted hot oil escape adds 26.85 mL outside. The routed containment design has less than half a millilitre of unallocated exterior allowance.
Limit of the closure model	The rated 80 ms closure assumes an intact close-coupled hydraulic buffer and a specified discharge curve. Trapped liquid can keep moving, a loaded seat can stall, and the assumed jet may miss the plate. Qualification requires simultaneous measurement of original-plane flow, seat motion and the separately collected spill.

What keeps the failed buyer inlet closed?

At each buyer the oil stays on the supply side of the existing inlet. A spring-loaded mechanical gate returns to its seat once a minute. Three independent conditions govern the next transfer.

Test or component	Result on the combined installation
Catch and fresh travel	The upstream catch must allow delivery. A resettable collar on the dry drive shaft then requires 0.640 reference m^3 of fresh forward movement per buyer. Stored entitlement to earlier oil cannot open the gate. The final clutch requires continuing forward motion.
Matched hidden loss	The catch was silent in both runs. The six-second hold admitted 1.136270 m^3 after loss. With the collar the same ten-second residual stroke admitted 0.000000 m^3 across the same two inlets. Both gates began the test seated.
Opening allowance	The largest residual was 0.565501 reference m^3 per buyer. After shaft and index error, the remaining rejection allowance was 29.37 L per buyer. A sustained stroke lets sale begin between 10.57 and 12.16 seconds.
Service to a healthy buyer	Eight piston pairs are down per train. All 80 paired replays met their schedules. The lowest required full-minute average was 400.117616 m^3/h. All 27,152 sale portions met the grade model. Flow pauses each minute while the gate earns permission to open.

Seller stock
Finite, assayed oil
→
Catch pickup
Latches on collected oil
→
Dry collar
Earns fresh travel
→
Buyer inlet
Closes when motion stops

This is the control sequence. Oil travels in a separate wet line from the seller stock to the buyer inlet. All new oil that crosses the inlet after failure counts against isolation.

A taller containment wall with overhead gas passages

The candidate retains the existing buyer inlet. Below it, a recessed floor and 6.8 m wall contain hot oil and water. Gas flows through upward takeoffs in two staggered rings. A conventional side pipe would be wider than the gap over the wall.

Test or component	Result on the combined installation
Waves after receiver loss	At hour 60, oil concentrated on 65% of the usable floor drove the wave to 6.007 m. The 6.8 m wall retained the liquid and preserved 0.793 m freeboard. At 55% initial coverage the wave overtopped the same wall after 1.145 s. Beyond that point outside spill depends on the surviving enclosure.
Gas pressure at the same load	At 24 working overhead passages the modeled peak was 170.499 kPa absolute, below the 171.325 kPa ceiling. With seven passages it reached 231.595 kPa. The roof takeoffs and independent supports must survive for either routing assumption to apply.
Combined resource limits	With the dry collar, recessed floor, taller curb, pulse cells and overhead gas paths, counted cut is 72,112,894.8 m^3 and worst-hour water is 0.665047 L. The conditional exterior oil total is 0.999504 L, leaving 0.496 mL. The three new floor and gas-path fills each assume at most 0.005 ppmv condensables including measurement error.
Commercial and physical limits	The 16 m pipe extensions alone add 25,876 tonnes of double-shell steel. The oil budget covers 137,885 m^2 of cleaned surfaces. The required roof survival, minute seal leakage and independent support behavior remain unverified. The calculations do not yet support deployment.

What happens when the buyer fails during delivery?

Each test below measures new reference-volume oil crossing the existing inlet after true loss. Oil already inside the failed buyer, movement inside the seller catch and oil reaching the exterior have separate accounts.

Test or component	Result on the combined installation
Loss with the valve open	At second 20 with ten seconds of residual motion, 1.442857 m^3 crossed. Disabling the clutch increased this to 2.050541 m^3. The clutch must stop flow within 0.10 s after shaft motion ends.
Timing sweep	Of 240 equally spaced quarter-second loss timings, 3 had zero transfer. The largest was 1.442857 m^3. These are deterministic design tests and supply no probability of an incident.
Longer residual or continuing drive	Twelve seconds of residual motion from reset admitted 0.219163 m^3. With the shaft continuing just as at a healthy buyer, 6.786017 m^3 crossed in the first full minute. The controller needs an independent physical difference between those two states to distinguish them.
Inlet restriction	Reducing the available port from 75 to 70 L/s per buyer lowered genuine delivery to 375.731 m^3/h. Only 9 of 20 schedules passed.

Can an independent buyer measurement reduce the transfer?

A design option alternates two four-cubic-metre seller cylinders. It compares dispensed oil with an independently supported buyer's mass gain. A deficit trips a second isolation device.

Test or component	Result on the combined installation
Independent loss measurement	At second 20 the signal tripped 1.50 s after loss. New oil across the failed inlet fell from 1.442857 to 0.235224 m^3. Among 240 offsets, 3 transferred zero. The largest was 0.242777 m^3.
A loss already in progress	When stored buyer oil began draining before the inlet opened, the second interlock detected the imbalance and admitted 0.000000 m^3 of new oil. Oil already in the failed receiver remains an independent containment load.
False proof	With continuing drive, independent weighing limited first-minute crossing to 0.225815 m^3. A spill carried by the same support admitted 6.786017 m^3. A jam in the isolation device also defeated the trip.
Scale and feasibility	The modeled mass-change uncertainty is 20 kg at each endpoint, about 1.47 parts per million of the full buyer oil mass. Heat, piping thrust, waves and foundation motion act on the same load links. The additional seals, pressure and lot timing require a combined test before this option can earn mission credit.

Metrological performance of load cells · OIML R 60-1

Water, exterior oil and construction

Two dry index cabinets share the existing mechanical drive. Each uses an allowance for a two-by-three-metre foundation. Exterior oil combines all rated sources at the specified fluid purity.

Test or component	Result on the combined installation
Water at both buyers	Rated ingress stays at 0.648383 L in the worst rolling hour. A single additional 60 mL release in that hour gives 0.708383 L and exceeds 0.699.
Oil reaching the exterior	The dry cabinets and rated plant sum to 0.996368 L over 72 h. Only 3.632 mL remains. At 10 ppm condensable oil in escaping receiver gas the result is 1.028072 L. The rated calculation uses 1 ppm.
Earthworks and drive	The two foundations add 9.36 m³, for 72,070,621.90 m³ against 72,200,000 m³. Shaft loading assumes a 2 Nm limit per dry index. Actuating the loaded heads requires a separate local energy source.
Sealing acceptance	A closed seat leaking 0.1 mL/min at each buyer would transfer 0.864 L in 72 h. The zero-crossing run assumes tight seats and excludes trapped liquid beyond them. Measure seat seepage and weigh the independent buyers and catches on the same clock.

Basis for isolation and verification · HSE HSG253

Can the pulsed inlet deliver at pressure?

A hydraulic option places two sealed nitrogen buffer cells upstream of each buyer gate. It retains a 14 m wet transfer line and a separate 315 m dry witness shaft. One 10 m³ gas cell per buyer may be unavailable.

Test or component	Result on the combined installation
Drive and storage	At 10 m rise, one working cell can accommodate the modeled charge before the late opening. The two buyers each need their own drive, buffer and shutoff. A rising line, a partly obstructed buffer throat or a mistimed crossover changes the required hardware.
Operating envelope	At the late opening, the pressure model uses a 0.25 m pulsed column. At 10 m rise its demand is 28.22 kW per buyer. Upstream and local faces have different pressure ratings. The model assumes the diaphragm moves freely and the gate can carry differential pressure.
Equipment ledger	The buffer layout gives 0.648394 L/h and 0.996461 L outside under rated assumptions. Its foundations add 134.4 m³ to the comparison installation. Dry-cabinet pads and any mass-balance upgrade require their own allowances.
Failed controls	One 75 mL wash pocket raises ingress to 0.723394 L/h. A one-square-micrometre effective opening at each buyer that also leaks outside gives 1.000492 L over 72 h.

How tight is the drive and handoff margin?

A physical inlet option uses a two-plunger meter with 35 L pockets. An interlocked distributor meters the oil and prevents a charged upstream buffer from emptying through a stopped gate.

Test or component	Result on the combined installation
Pressure and stored work	At 10 m rise the late-opening trial needs 7.327 GJ per buyer against 7.405 GJ available. At 15 m the same equipment needs 8.538 GJ. A lower usable stored energy or higher lift can end service early.
Switching speed	The two plungers switch 102 times per minute. The average additional interruption allowance is 2.312 ms per switch. At 20 ms, gross mechanical capacity falls to 393.353 m^3/h before water, losses or valve ramps.
Inventory and collection	After filling the four cells, meter and new passages, the remaining unallocated source stock is at least 6.078 m^3 per buyer. With one intact 80 m^3 catch per buyer and an open route to it, static collection headroom is 24.862 m^3 each.
Construction test	Cycle the distributor through a full delivery day with one buffer isolated. Measure the valve position, buffer pressure, pump work, buyer volume and every crossover interruption on the same time base. The assumed millisecond handoff and zero-flow seal are consequential procurement requirements.

Where does the oil go at hour 60?

Cases 12, 18 and 19 lose a loaded receiver after sixty hours of sale. Each train, pressure rule and gas-access assignment was replayed to the moment of loss. The protective wall and its gas system must accept the same simultaneous event.

Test or component	Result on the combined installation
Inventory actually present	Each buyer had received up to 12,214.83 reference m^3 before loss. At the specified hot expansion this is 12,825.57 m^3. The model admits 1,531.37 m^3 of separate intercepted water in the first two seconds. Unused seller stock stays upstream.
First two seconds	With the drains blocked the local structure needs 14,356.94 m^3 of usable capacity per buyer. Even allowing the maximum gravity drainage throughout both seconds leaves at least 10,940.98 m^3 locally. The gas trial conservatively holds all existing liquid.
Independent retaining wall	A 5.5 m wall within the 5,000 m^2 buyer footprint reserves 0.75 m freeboard and 600 m^3 for debris. With 80% usable area, pooled liquid reaches 3.96 m. At 60% the wall cannot hold the modeled load with the required freeboard. Its roof and supports need independent load paths after the original vault fails.
Gas and structure	After debiting wall, debris and obstructions from gas space, a flush floor and 30 open gas passages peak at 167.832 kPa against 171.325 kPa. With 24 passages, pressure peaks at 178.866 kPa. At 36 passages with thermal contact lost, pressure and gas temperature exceed their limits. These results depend on an intact new shell.

What does the combined installation require?

These totals book the 5.5 m retaining wall, 1.20 m floor recess, dry collar pads and four pulse cells together. All three nitrogen charges for the new floor volume are counted in the same hour. Separate failures can still defeat these resource limits.

Test or component	Result on the combined installation
Earthwork and water	The combined counted cut is 72,104,260.9 m^3, leaving 95,739.1 m^3. Rated ingress including the pulse cells and two purge fills is 0.654478 L in the worst hour. Both buyers share the 0.699 L limit.
Exterior oil	With each new floor gas charge limited to 0.010 ppmv condensables including analyzer error, plus the separate pulse cell, cabinet and liner charges, the total is 0.998779 L in 72 h. Only 1.221 mL remains for uncharged loss. This needs independent containment of every wetted surface after the event.
Work and delivery	The depressed-floor option at a 10 m supply rise needs 7.3277 GJ per buyer including dry index work, against 7.4052 GJ available. The calculated minimum static delivery-head margin is 2.018 kPa. Splash, entrained gas and peak transient pressure can still affect delivery.
Alternative floor level	With a flush floor, full inventory adds about 9.41 kPa at the buyer. At 10 m rise the calculated hardware can accept only 4.762 kPa above the original buyer pressure. An 8 m rise with 162 kPa gas fill passes the separate pressure, power and work calculation. siting the upstream supply at that elevation needs its own construction account.

Can the retaining wall coexist with delivery?

The proposed retaining structure displaces part of the operating pool. Its normal oil level and remaining gas space change the pressure required for delivery and for isolation.

Test or component	Result on the combined installation
Flush floor	At hour 60 the reduced area adds 7.820 kPa at the existing nozzle. The pulse-cell option has only 2.018 kPa spare. These configurations cannot inherit each other's passing delivery result.
Depressed floor	Lowering the floor by 1.20 m keeps the healthy transfer nozzle and gas roof at their existing elevations. The static nozzle head is 3.477 kPa lower at hour 60 and 1.886 kPa lower at full source inventory. An initially unsubmerged nozzle can entrain gas and change product quality.
Gas acceptance	With the lowered floor and 30 open gas passages, the hour-60 pulse peaks at 162.908 kPa. With 24 it reaches 172.112 kPa and exceeds the 171.325 kPa limit. Foundation survival, local pressure waves and exterior leakage still determine the full mission.
Resources	The lowered-floor study books 72,104,127 m³ of paired cut. Its additional dry gas raises rated water to 0.650411 L/h. Pulse-cell foundations and wet inventories belong to a separate equipment account. Containment also depends on sealing the whole perimeter through hour 72.

Which end-to-end cases have passed?

The twenty cases include six recoverable incidents requiring 72 hours of sale, five requiring 60 hours followed by isolation and nine requiring immediate isolation. Each also owes 72 hours of containment.

Test or component	Result on the combined installation
Registered operating checks	The selected collar met flow, sale grade and registered stop requirements in 20 of 20. Each of the 56 scheduled stopping variants also passed with the upstream pickup silent at reset.
Receiver collapse	Cases 12, 18 and 19 require coupled retention of liquid and gas. At the design full load of 16,678 m³ per buyer, at least 13,262 m³ must still be held locally after two seconds, even at the maximum assumed gravity rate. The amount on hand at incident time is a separate input.
Ground and fluid conditions	At +0.2°C and 25 mm of relative movement the modeled hot-water head is 1.341248 kPa above saturation. At 40 mm, cases 12, 18 and 19 miss the 1.33 kPa gate. Water, condensable oil and installation movement all affect the result.
Whole-mission score	0 of 20 demonstrated every requirement. Seventeen have no assigned loaded-receiver collapse. Those cases still require a compatible pressure, support and exterior-release model on the selected installation. A model pass and a physical qualification are separate decisions.

How water stays outside the sale line

Six exposed gas passages serve two buyers. Each passage has two independently chilled, dry steel condensers. The model loses one condenser at every passage. External strain pickups sense the sale pipe through intact metal. Four water-filled instrument connections are eliminated.

Test or component	Result on the combined installation
Water at the buyer	At 88°C saturated inlet air and 10 Pa inward pressure, the six passages can admit 7.74 m^3 of air per hour. Steel initially at 2°C stays below 10.9°C at the cold surface through a two-hour assay plus 72 h of service. Condensate settles in blind collection pots.
Severe rain and dry gas	The trial charges a 200 mm storm collected over 16 times the opening area, up to 10% of that rain in fine mist, 0.2 ppmv water in all added gas, and one part per million of the 161,196 L falling into the outer galleries. The combined worst hour is 0.648383 L. Shortening every dry outlet bore from 100 mm to 1 mm gives 0.699865 L.
Limits of the weather test	Doubling the gallery rain fraction gives 0.821 L. If all the vent rain remains as fine mist the total rises to 2.127 L. A downstream wet opening can bypass every condenser.
Actual product	Assigning the complete 6.763 L over the full exposure to each sold portion in turn, all 27,152 portions met the modeled grade. The highest water fraction was 0.6175%. The final stock allowance is 6.262 m^3 per buyer in the limiting schedule.

Pressure relief without waiting for a valve

A four-metre enclosed extension over each buyer connects continuously to 48 pressure-matched gas passages. Twelve receiving shafts stay below each buyer for gravity capture. Thirty-six blind gas vessels move above grade and supply no gravity storage for oil.

Test or component	Result on the combined installation
The first two seconds	All gas spaces start at 105.825 kPa absolute. At the assigned 0.15% flash by mass, a full buyer peaks at 150.905 kPa with one passage unavailable. With 18 unavailable it reaches 168.167 kPa. The pressure ceiling is 171.325 kPa.
Failed pressure tests	With 24 unavailable the peak is 177.821 kPa. With all passages blocked it is 292.298 kPa. With 1% flash, pressure reaches 411.518 kPa and gas reaches 132.50°C. At 30 available passages the passing flash limit is close to the assigned 0.15%. the crude's actual gas release is unmeasured.
Liquid remaining at the buyer	After one deep shaft is lost, static capacity exceeds the hot-liquid allowance by 2,903 m^3 per buyer. Even with 4 m of gravity head, moving all the hot oil takes at least 8.87 s. The successful native gas pulse starts with oil still held at the buyer.
A second basin	A separate closed 110 m square basin retained liquid for 9 s with drains blocked. Its corners intersect the selected gas-vessel ring. It needs 27,650 m^3 of separate excavation and a compatible gas path. This basin earns no credit in the selected installation.

Where the oil goes after a line break

A closed outer gallery surrounds the entire short product line and both end connections at each buyer. Cooling plates inside each gallery absorb heat without adding a pressure penetration. The same pair of galleries is used for the leakage, temperature, water and excavation accounts.

Test or component	Result on the combined installation
Blocked drains	The loaded guard and line send 56.232 m³ into one gallery. With the drains blocked, hot rain and all modeled steam heat included, a two-second pulse peaks at 1006.28 kPa absolute and 120.00°C. Losing half the thin-plate area raises the temperature to 147.01°C.
Exterior oil through 72 hours	At an assumed 2 ng/L condensable oil in the installed auxiliary water, the conditional total is 0.996368 L. It includes both short liquid leaks, one part per million of the gallery flash and one part per million by mass of the main receiver gas that escapes in the 72 h comparison. Its 2,853 kg of escaping light hydrocarbon makes composition decisive.
Failed environmental controls	Ten parts per million of the escaping main-receiver hydrocarbon condensing or carrying oil gives 1.028072 L. Retaining the original 5 ng/L auxiliary fill gives 1.030034 L even at one part per million. A continuously supplied path through all barriers releases 67.148 m³ in the separate 72 h control.
Acceptance threshold	Once the other listed charges are paid, 2.031 parts per million by mass of the escaping main-receiver hydrocarbon would exhaust the litre. The actual condensable and aerosol share and the installed liquid purity have not been measured. The 120°C replenished-gas comparison also exceeds the receiver pressure ceiling before hour 72.

How the receiver knows when to stop

The real buyer port and the original qualified stock are retained. The mechanical shaft permits flow when the buyer appears able to accept it. An internal loss can leave the port engaged and show the same movement as a healthy buyer.

Test or component	Result on the combined installation
Every required delivery minute	Both gas-access assignments and both pressure rules were run with eight piston pairs unavailable on each train. The minimum genuine oil rate is 400.432 m^3/h after water, solids, returned oil and two short exterior losses. Six incidents require all 72 h of service, five require 60 h, and nine require immediate isolation.
An unannounced loss	Cases 9 and 12 admit the same first 10 s of crank movement after hour 60. If receipt pressure and engagement also match, waiting for a difference limits the healthy minute to 348 m^3/h on the original inlet. Meeting 400 then requires at least 0.867 m^3 during that shared interval.
Two physical cutoff trials	A larger inlet with a periodic cam meets all registered delivery schedules when loss coincides with a reset. Moving the loss ten seconds into the cycle delivers 2.262 m^3 late. A toothed displacement lock limits late delivery to 6 L when actual receipt motion stops. An internal leak that keeps the receipt piston moving defeats that limit.
Where run-on belongs	The registered stop requires zero new oil crossing into the failed buyer. Motion can continue into a finite seller-owned catch on the supply side. The simulation must show which route takes the oil. Crediting a sale or sending oil through a failed buyer cannot be corrected by relabeling it after the event.

Excavation and the hot-water limit

Relocating the blind gas storage reduces excavation while increasing the load on surface foundations. Pressure at the hot-water reference changes when the new foundations move relative to it.

Test or component	Result on the combined installation
Counted works	Across both trains and both buyers, the selected layout uses 72,070,613 m^3 against 72,200,000 m^3. Remaining allowance is 129,387 m^3. It includes the closed gallery, cooling supports and all twelve condenser foundations.
Surface demand	The gas installation reserves 8.26 additional hectares of surface plot. The design identifies 57,248 tonnes of additional gas-system steel. The dry condenser stores add 720 tonnes of steel. Land, foundation motion and access remain material design constraints.
Hot-water pressure	The native floor is 2.099 kPa above saturation. A 0.2°C hotter film plus 25 mm of additional relative elevation leaves 1.341248 kPa, above 1.33 in 20 of 20 cases. With 40 mm the minimum falls to 1.194149 kPa and 3 cases miss.
What a site test must establish	Measure the pressure and level at the hot-water reference under the installed loads. Check the worst local elevation change against the thermal trial. The amount of excavated rock alone cannot establish that the water margin survives.

A rain roof over the transfer gallery

A welded outer roof sheds water before it enters the gallery around the oil line. It has its own supports and four free discharge edges. The oil pipe and the gallery wall remain intact. This hydraulic trial compares a design option with the selected receiver.

Test or component	Result on the combined installation
Storm and openings	Each roof collects runoff from 443.3 m² at 200 mm in one hour. The modeled seam openings on each roof together have the area of a single 0.15 mm diameter hole. Every drop passing those openings is charged to the product. The calculation also retains 0.476 L from the other water sources.
Two working discharge edges	The total is 0.626802 L across both buyers. With one edge open it is 0.654420 L. Both are within 0.699 L. The one-edge case can accommodate an equivalent seam opening only up to 0.168 mm per roof.
Blocked edges or direct spray	All edges blocked gives 0.758700 L. One edge open with a 0.30 mm defect gives 1.189736 L. Adding 0.25 L of direct spray below the roof to the two-edge trial gives 0.876802 L. Each exceeds the limit.
What the trial covers	The simulation screens rain drainage and leakage over one hour. It leaves wind-driven entry, roof deflection, support loading, exterior residues and interference with the gas passages open. The selected excavation and 72-hour delivery figures exclude this optional roof.

Can a stopped buyer safely receive run-on?

Oil movement, seller-side capture, crossing into the buyer and exterior release are four separate measurements. They can give different answers in the same shutdown.

Test or component	Result on the combined installation
Prescribed stop replay	The 56 stop comparisons recorded zero new buyer oil and up to 1.160 m^3 in the seller-side catch. The underlying simulation switches routes when the event occurs. The physical equipment must direct oil to that same destination.
Port already blanked	A physical blank ahead of the failed port put 1.229 m^3 of expanded liquid into the upstream catch and zero across the buyer boundary. This case assumes the blank is in place before loss and the catch is connected.
Hidden internal loss	A disappearing receipt signal with a finite spring closure admitted 11.40 L at reference conditions. If an internal leak kept the return moving, 1.171 m^3 crossed into the failed buyer. The intact downstream enclosure retained the oil. A one-percent bypass of the guard would add 12.29 L outside.
An upstream trip signal	All 28 stopping train histories accrued over one litre of missed flow at the upstream station by five seconds. The enlarged buyer inlet leaves at most 8.29 s to transmit this signal after allowing for local closure. A hidden loss can preserve upstream flow. Signal travel and available pressure at the higher peak rate still need a combined test.

Can a separate closed basin take the whole release?

A separate 110 m square basin receives liquid while the gas vessels move outward. Greater gas space reduces pressure, but it also puts more water-bearing gas next to the product.

Test or component	Result on the combined installation
Plan and earthwork	Shifting the ring clears the basin corners by 0.22 m in plan. The 16 m basin layout uses 72,127,710 m^3 of counted excavation and leaves 72,290 m^3. Construction tolerances, settlement and piping clearance remain open.
Short pulse	At least 13,262 m^3 per buyer needs local storage after two seconds even at the upper gravity drain rate. The sealed 16 m basin reaches 214.95 kPa absolute and 167.41°C at full access. The limits are 171.325 kPa and 120°C.
Gas space and water	The closed equilibrium model needs 290,619 m^3 of readily accessible gas space per buyer to meet both endpoints. With all that space reachable, water is 0.756 L at 0.2 ppmv moisture in the added gas and 0.659 L at 0.02 ppmv.
Partial access	If a quarter of the gas space can participate, the calculated total height rises to 182 m. Even the dry-fill endpoint reaches exactly 120°C. A larger structure, access to the gas within two seconds and its exterior containment through hour 72 remain unverified. The earthwork estimate above applies only to the 16 m option.

A six-second hold before buyer delivery

The buyer valve closes at each minute boundary. A volume pickup in the upstream catch trips at one litre and latches shut. A six-second hold gives that signal time to reach the valve before it can open. The buyer needs a larger inlet to deliver the accumulated oil in the rest of the minute.

Test or component	Result on the combined installation
Input to the controller	All 28 stopping train histories exceeded one litre of catch inflow by five seconds. The cumulative catch inflow stayed at zero throughout all 22 train histories with service due. The comparison uses physical volume as its input. No incident number is sent to the controller.
Time to isolate	The compared pilot line is 300 m long. At 700 m/s the model allows 0.429 s for transmission and 0.047 s for local closure. The six-second hold leaves about 0.52 s after a five-second detection. These times assume that the pilot remains connected and the valve moves under load.
Prescribed duty	The controller met the flow, stop and lot checks in 20 of 20 registered cases. The lowest qualifying rate was 400.118 m^3/h. The largest new transfer across a required stop was 0.000000 m^3 at reference conditions. The screen charged sale-side losses and preserved the finite stock.
Outside the registered timing	The opening rule responds to fluid arriving at the upstream catch. A hidden loss confined to the buyer can keep this catch dry. A slow signal can also arrive after the valve opens. A whole-case claim requires the buyer, inlet drive, water barrier, modified foundations and exterior capture to work together through hour 72.

Combined cases 01–10

Every named case requires 72 hours of containment. The paired delivery and product results cover four gas and pressure settings with eight piston pairs down in each train. An automatic stop at a scheduled minute boundary and sudden loss while already flowing are separate trials.

Incident	Sale, h	Lowest m^3/h	Off-spec / tested	Missed minutes	Full case
01. Source closing energy lost and conventional valves jammed	0	—	No sale due	0	Open
02. Terminal closing energy lost and conventional valves jammed	0	—	No sale due	0	Open
03. Source and terminal closing energy lost with jammed conventional valves	0	—	No sale due	0	Open
04. Trigger inlets blocked with jammed conventional valves	0	—	No sale due	0	Open
05. Pilots blocked with jammed conventional valves	0	—	No sale due	0	Open
06. Sleeves torn with jammed conventional valves	0	—	No sale due	0	Open
07. Sleeve closing force tripled with jammed conventional valves	0	—	No sale due	0	Open
08. 5 mm^2 seat gaps with jammed conventional valves	0	—	No sale due	0	Open
09. Three route boundaries lost	72	400.044	0 / 2,672	0	Open
10. Independent heat envelope penetrated	72	400.044	0 / 2,672	0	Open

What prevents qualification

Each result requires intact spill containment and a verified safe stop. No physical measurement establishes the site response or exterior release. Cases 12, 18 and 19 also require the loaded receiver to accept the coupled liquid and gas pulse.

Combined cases 11–20

Every named case requires 72 hours of containment. The paired delivery and product results cover four gas and pressure settings with eight piston pairs down in each train. An automatic stop at a scheduled minute boundary and sudden loss while already flowing are separate trials.

Incident	Sale, h	Lowest m^3/h	Off-spec / tested	Missed minutes	Full case
11. Closed catch boundary lost	0	—	No sale due	0	Open
12. Loaded collapse and outer-vault loss at 60 h	60	400.044	0 / 2,224	0	Open
13. 100 mm source-gas wall breach	72	400.044	0 / 2,672	0	Open
14. Gas heat transfer degraded	72	400.044	0 / 2,672	0	Open
15. Catch heat transfer reduced at 60 h	60	400.044	0 / 2,224	0	Open
16. Local pocket outer boundary lost	72	400.044	0 / 2,672	0	Open
17. Catch heat transfer lost at 60 h	60	400.044	0 / 2,224	0	Open
18. Enclosure gas starts at 86°C	60	400.044	0 / 2,224	0	Open
19. Catcher shield fully open	60	400.044	0 / 2,224	0	Open
20. All current quality evidence falsified	72	400.044	0 / 2,672	0	Open

What prevents qualification

Each result requires intact spill containment and a verified safe stop. No physical measurement establishes the site response or exterior release. Cases 12, 18 and 19 also require the loaded receiver to accept the coupled liquid and gas pulse.

Reference installation and dry receiver

Separate simulations of two alternatives show how changing the receiving equipment affects the sale and containment results.

0.555 L
Dry receiver · severe rain hour

400.438 m³/h
Dry receiver · genuine flow

0 / 20
Complete retrofit cases

The dry receiver qualifies 0 of 20 complete simulated missions. Its water and flow results are conditional on an intact delivery boundary. The reference installation separately passes 9 of 20 complete missions, all immediate-isolation cases. The reference results below apply to its own equipment.

Reference design requirement	Reference design result for both trains
Recoverable damage	Each of six recoverable records requires 400 reference m³/h in every minute for 72 hours. The native delivery model supplies at least 29,051 m³ per case with eight piston pairs down per train.
Lost receiving endpoint	Nine records demand immediate isolation. Five demand normal emergency service to hour 60, followed by automatic isolation. The registered post-stop delivery is zero in each.
Liquid and vapor outside	The paired charge reaches 0.998720 L. This includes 0.081461 L in auxiliary water and surface residues, and 0.066700 L in auxiliary nitrogen at 1 ppt condensable hydrocarbons as toluene equivalent. Guard fill requires ≤0.005 µg/L and clean metal ≤0.10 µg/m². The 8 mm dry support grid adds 0.000614 L of surface residue to the exterior account.
Earthwork	71,898,018 m³ booked across both trains. The ceiling is 72,200,000 m³. This quantity depends on the assumed ground and construction geometry.
Rapid foundation response	23/23 rated foundation traces met the charged support criteria including two carbon-steel protection-bent outages, two of four dashpots unavailable, and rerouted grade caps and rails. Maximum 1.879 MPa ground, 344.4 MPa blade, 0.36642 MPa grout. Independent failure of half the gas in every foot gives 165.6°C vs 160°C.

Dry receiver comparison

Water and flow pass their modeled tests in the specified rain trial. A concealed receiver loss can leave the mechanical key engaged and allow a late sale. The fresh oil and vapor that could escape if both the pipe and its outer sleeve open still exceed the available exterior allowance in an adverse trial.

How does the buyer keep water out?

The wet drive ends at a blind pressure wall. Across 315 m, a solid shaft conveys piston movement through magnetic couplings. A weight at the buyer supplies the pumping work. Only a short, primed local pipe carries sale oil. Four sealed pressure gauges have no connection to a water supply.

Component	Result on the paired installation
Finite gauge inventory	Even if all four metal gauge capsules rupture together, their dimensions limit external water to 0.113 L across both buyers. The model also condenses the entire original and added nitrogen moisture charge, 0.170 L, into that hour.
Gas pressure through hour 72	Three weighted holders per buyer begin with 1,300 extra m^3 each. Two surviving holders can travel 3.8 m. Across 691,200 train-minutes the minimum cold gas reserve was 553 m^3. A common wet pipe around the solid shaft would defeat the separation.
Rain and condensation	Dry weather gives 0.299 L in the worst rolling hour. The eight-times rain test gives 0.555 L. sixteen times gives 0.811 L. The limit is 0.699 L across both buyers in any rolling hour. The study assigns no instantaneous flow bound to a ruptured capsule.
Retained construction water	The eight-times rain trial leaves 144.2 mL for all other water that reaches the oil that hour. In a 72-hour preinstallation drying comparison, a 2 mm pool with a 10% open escape area dries. at 5% opening the modeled residue is 6.05 L. A closed pocket can release its entire contents later.

Can the last delivery still be sold?

Two solid timing shafts transfer a displacement signal. Two independent falling weights per buyer are charged before the incident. With one weight unavailable, the surviving weight drives the original authenticated stock through the actual buyer port.

Component	Result on the paired installation
Minimum genuine oil	Eight pairs are unavailable on each train. The 1.0048 drive ratio delivers at least 400.438 m³/h after charging the whole rain-hour ingress to one minute, the fluid assay tolerances, and oil seeping back into the guard. The working weight supplies 7.405 GJ against 6.439 GJ in the drive screen.
Original stock and quality	Both the line prime and 33.535 m³ of make-up per buyer come from original stock. With the articulated extension charged, 6.262 m³ remains in the limiting buyer. The one-hour storm gave 0.5296% water at most over 27,152 full or partial transfers. An independently primed portion exposed to an unaccounted 20 L exceeded the 1% specification.
Physical disconnect	The two flush heads close in 46.6 ms. With 0.20 m of retained travel, the 2.5 m/s pull leaves 33.4 ms and zero new sale in that separation trial. One closed catch per buyer can be lost.
Hidden endpoint loss	A loss inside the receiver can leave the port engaged. The shaft can then move 1.171 m³ across the two buyer ports after the required stop. Its motion alone cannot distinguish a buyer still accepting oil from a hidden loss.

Can the retrofit contain a loaded loss?

The candidate adds covered wet collectors, separate gas holders, double-shell catcher shafts, and closed flash-gas vessels. The total-loss test charges the exposed oil, displaced nitrogen and flash gas to the same receiving installation.

Component	Result on the paired installation
Construction	Identified excavation is 72,194,956 m^3 across both buyers and both trains. That leaves 5,044 m^3 for unbooked foundations, cooling hardware and site preparation. Extra rock removal can exceed the limit.
Exterior oil	Original oil sources, receiver and line surfaces, the new holder rims, and both sets of cooling plates total 0.999889 L before any new bulk oil or entrained vapor escapes. Only 0.111 mL remains. Oil left on a service-wetted pipe must be captured separately.
Two-second flash	With 3.4 million m^2 of dry plates per buyer, the two-region model at the specified heat transfer coefficient and insulation value of 0.025 W/m^2K starts the plates at 44.3°C after 72 hours. Its 1% flash peaks at 131.0 kPa absolute and 120.0°C. With insulation at 0.10 W/m^2K the gas reaches 147.1°C.
What prevents acceptance	The first small gas space at the buyer can heat and pressurize before the rest of the bank is accessible. The first seconds, the oil-wet exterior paths and hidden losses with the receiving key still engaged require evidence on this installation.

What happens during a sudden receiver loss?

The first gas space available at a loaded buyer is only 1,253 m³. The pressure in that space and oil crossing the outside of the transfer pipe determine whether the larger receiving banks can protect the installation.

Component	Result on the paired installation
Pressure in the first gas space	At full load, a two-second release with 0.15% flash by mass reaches 118.874 kPa absolute and 101.75°C when the modeled ports begin opening at 0.10 s. The limits are 171.325 kPa absolute and 120°C. At 0.30 s, pressure reaches 288.112 kPa. The measured opening response under load is unknown.
Transfer pipe jacket	One isolated compartment holds 42.10 m³. It contains the modeled line inventory with 6% flash at 970.7 kPa absolute against a 1,200 kPa limit. If the whole dock guard empties into it, the minimum space needed is 59.37 m³ even before flash.
Oil escaping both barriers	When the modeled oil path continues through both walls, 6.03 mL escapes before closure. The nominal oil headroom is only 0.111 mL, before the optional jacket contributes another 0.0006 mL of residue. On these inputs the one-litre limit is exceeded.
Evidence required	A full receiver test must record pressure at the first gas space and the opening delay, weigh everything crossing the exterior boundary, and independently measure what reaches a disabled endpoint while its transfer joint remains engaged.

Dry receiver cases 1–10

Every comparison case owes 72 hours of containment. The flow column gives the lowest genuine oil delivery in a required minute. An immediate stop owes zero hours of sale.

Case and incident	Sale duty, h	Flow, m^3/h	Stop and sale evidence	Full mission
1. Source closing energy lost and conventional valves jammed	0	—	Stop on arrival. No sale owed.	Open
2. Terminal closing energy lost and conventional valves jammed	0	—	Stop on arrival. No sale owed.	Open
3. Source and terminal closing energy lost with jammed conventional valves	0	—	Stop on arrival. No sale owed.	Open
4. Trigger inlets blocked with jammed conventional valves	0	—	Stop on arrival. No sale owed.	Open
5. Pilots blocked with jammed conventional valves	0	—	Stop on arrival. No sale owed.	Open
6. Sleeves torn with jammed conventional valves	0	—	Stop on arrival. No sale owed.	Open
7. Sleeve closing force tripled with jammed conventional valves	0	—	Stop on arrival. No sale owed.	Open
8. 5 mm^2 seat gaps with jammed conventional valves	0	—	Stop on arrival. No sale owed.	Open
9. Three route boundaries lost	72	400.438	Sale due throughout	Open
10. Independent heat envelope penetrated	72	400.438	Sale due throughout	Open

Successful and adverse trials

The tested clean separation closes the buyer face. A hidden internal loss can leave the key engaged. Positive flow and passing lot checks during a sale do not establish containment or safe isolation. All 20 dry-receiver missions remain open.

Dry receiver cases 11–20

Every comparison case owes 72 hours of containment. The flow column gives the lowest genuine oil delivery in a required minute. An immediate stop owes zero hours of sale.

Case and incident	Sale duty, h	Flow, m^3/h	Stop and sale evidence	Full mission
11. Closed catch boundary lost	0	—	Stop on arrival. No sale owed.	Open
12. Loaded collapse and outer-vault loss at 60 h	60	400.438	Stop at 60 h. Key held: 1.171 m^3 late.	Open
13. 100 mm source-gas wall breach	72	400.438	Sale due throughout	Open
14. Gas heat transfer degraded	72	400.438	Sale due throughout	Open
15. Catch heat transfer reduced at 60 h	60	400.438	Stop at 60 h. Key held: 1.171 m^3 late.	Open
16. Local pocket outer boundary lost	72	400.438	Sale due throughout	Open
17. Catch heat transfer lost at 60 h	60	400.438	Stop at 60 h. Key held: 1.171 m^3 late.	Open
18. Enclosure gas starts at 86°C	60	400.438	Stop at 60 h. Key held: 1.171 m^3 late.	Open
19. Catcher shield fully open	60	400.438	Stop at 60 h. Key held: 1.171 m^3 late.	Open
20. All current quality evidence falsified	72	400.438	Sale due throughout	Open

Successful and adverse trials

The tested clean separation closes the buyer face. A hidden internal loss can leave the key engaged. Positive flow and passing lot checks during a sale do not establish containment or safe isolation. All 20 dry-receiver missions remain open.

How the system acts on an incident

The installation keeps incoming crude and produced fluids, previously assayed delivery oil, and the water used to operate and guard equipment in separate inventories.

Feed	→	Pistons	→	Clean stock	→	Receiver
Isolate affected stock		Transfer stored work		Meter reserve oil		Stop at lost custody

The model follows material, pressure and inventory after the initial trip.

Two trains carry independent stores. With eight pairs unavailable in each train, the surviving pairs move the segregated sale reserve. Physical separation of an intact dry coupling closes the buyer face in the tested pull. An internal rupture can leave the coupling engaged, allowing stored energy to continue transfer. Retained liquid and gas still require containment.

Donor	→	Catch	→	Gas	→	Exterior
Park closed shutters		Isolate trapped oil		Expand in separate banks		Count every oil route

Internal transfer into a blind receiver counts as captured inventory.

Shutters provide two separation spaces. An independent gas pocket and vacuum receiver limit exchange at the parked donor. A covered catch receives spills. Separate vapor banks limit pressure as liquid displaces gas and hot oil flashes. Pressurized water layers surround penetrations and moving connections.

What the operator sees

The panel reports the registered custody duty, component evidence, exterior oil accounting and the full-case decision. A false reading cannot establish initial product quality. Incorrectly certified reserve oil fails its quality control.

How the sheet transfers force to the ground

The civil model assigns a coherent pressure change to the sheet. Both signs of load, added collar area, the loss of supports and the flexibility of the structure influence the reaction.

Element	Design and finding
Sheet and rack	A 2.403 MPa pressure challenge acts on 6,376 m² of original occupied mats plus the projected area of new blade collars. A 2 ms rise exercises the rapid response.
Compression seats	A 496 m by 368 m articulated frame distributes load through 713 proposed support positions. Opposed nitrogen chambers allow long movement while narrow shear blades carry lateral load. Two full seats and individual lost blades are included in the design checks.
Flexible response	23/23 rated foundation traces met the charged support criteria including two carbon-steel protection-bent outages, two of four dashpots unavailable, and rerouted grade caps and rails. Maximum 1.879 MPa ground, 344.4 MPa blade, 0.36642 MPa grout. Independent failure of half the gas in every foot gives 165.6°C vs 160°C.
Relative motion	With the guarded dock installed, all 20 pressure clocks pass. The least actuator headroom is 1,240.7 Pa. The 8 mm dry support grid gives 2.09922 kPa above saturation at the exposed water surface and 2.38245 kPa at the confined crown. The combined ground reaction reaches 1.89326 MPa against 2 MPa.
Installed mass	Each of 128 pickups uses 9,600,000 tonnes of tied foundation materials, purchased components and charge, incl crown/receipt and 3,770 tonnes residual trim. Up to 125,000 additional tonnes of protected exterior plant/captured fluid. Independent grade islands priced separately.

Where a component success stops

Sheet strain, support force, wet-seal travel, relative grade and customer delivery are different measurements. A positive bearing reaction alone does not bound the oil that crosses a moving sleeve or the pressure available at a customer takeoff.

Where the one litre can go

The limit covers liquid oil, condensable vapor, wetted surfaces, trace oil in clean water and openings that can connect to the exterior over the entire 72 hours.

Route or fault	Oil account
Bypass inside protection	Two independently supplied water barriers and two separated blind receivers guard wet, dry, vent and moving connections. An assigned one-part-per-million shortcut into a receiver adds to captured inventory and its pressure duty.
Guard endurance	The rated run includes one complete pressure plane down and the older water supply unavailable. Trial defects are present in all eight modeled regions per pickup. Dirty fill, doubled clearance and a lost collector are separate controls.
Moving joint	A 30 m sliding cuff separates wet and clean faces through the modeled stroke. Eight pressurized lands oppose outward oil transport. Travel, alignment, thermal expansion and seal wear determine whether that separation persists.
All charged inventory	The paired charge reaches 0.998720 L. This includes 0.081461 L in auxiliary water and surface residues, and 0.066700 L in auxiliary nitrogen at 1 ppt condensable hydrocarbons as toluene equivalent. Guard fill requires ≤0.005 µg/L and clean metal ≤0.10 µg/m². The 8 mm dry support grid adds 0.000614 L of surface residue to the exterior account.
Common opening	A one-part-per-million continuous path to the environment reaches 128.383 L. A separate common-bore control reaches 14.142 L.

Acceptance at a physical boundary

Collect and weigh liquid, aerosol and condensable hydrocarbon at all outer exits. Charge initial contamination and the upper uncertainty in tracer recovery. The purifier supplier specifies toluene-equivalent organics at its outlet. Each installed inventory needs independent certification.

Nitrogen purifier outlet specification · Entegris

Power for the full operating period

Closed nitrogen and water drives supply blower shaft work independently of utility electricity. The proposed drive uses ten piston tubes per parcel. The rated calculation disables a tube at each working parcel, loses two parcels and limits access to 73% of the bank.

Duty	Calculated result
Start and run	The 5.5 m gallery purchases 1,262 blower parcels per train. Startup takes 128 s on the modeled clock. All 80 thermal operating states pass, peaking at 116.067°C. Rated shaft work is 1,327.8 GJ against 1,182.9 GJ including reserve.
Stored energy	Pressure, usable stroke, mechanical efficiency, charge loss and return pressure enter the work integral. The panel counts the trace oil in the full paired working-water charge.
Vapor at a damaged pickup	The donor and catch each have three large vessels with one unavailable. The donor has 3,200 m³ of contiguous additional space and a 1,852 m³ net crown. The two volumes exchange gas through a restricted internal passage. The 130 m lines have 70 mm pressure walls. The sphere inner walls are 140 mm thick.
Combined challenge	All 20 case clocks stay inside the 120°C and 70 kPa gauge limits. The refined donor reaches 117.48°C and the refined catcher 114.20°C. Loss of segregation of the water exits sends the donor to 122.10°C.
Product acceptance	The qualified reserve requires independent commissioning assays and continued physical segregation. A widespread false commissioning reference can invalidate every later custody sample.

Temperature and pressure during the pulse

A two-second arrival can govern even when the average over an hour is modest. The gas calculation carries mass, heat and retained liquid through the fast pulse and onward to hour 72.

Which fluid reaches the customer?

Two 315 m pipe extensions separate the grade equipment from the main foundation. A genuine recovery minute requires sale-quality product through the physical custody boundary.

Check	Reported evidence
Surge at the local stop	Each pickup has four finite 52 m^3 surge cylinders with 16 m^3 of verified oil initially in each. The high-flow case moves 13.21 m^3 in either direction. The added line cannot displace oil into a disconnected customer.
Product pressure	With the guarded dock installed, all 20 pressure clocks pass. The least actuator headroom is 1,240.7 Pa. The 8 mm dry support grid gives 2.09922 kPa above saturation at the exposed water surface and 2.38245 kPa at the confined crown. The combined ground reaction reaches 1.89326 MPa against 2 MPa.
Crude delivered	The hydraulic delivery is 403.492 m^3/h. Accounting for original water, sediment, oil loss and new water gives at least 400.395 m^3/h of genuine source hydrocarbons in the limiting minute. Product quality is assessed separately at custody.
Water entering a selling pipe	The native assay uses 44 m^3 of physically isolated product and a 2-hour hold. The true batch limits are 1% water by volume, 5 mg/kg organic chloride and 0.05% sediment by mass. One litre is the witness sample volume. The separate exterior-oil allowance is 1 L across both trains. Existing dry-stock volume and passing samples alone cannot establish composition at the buyer after wet connections.
Failed samples	In case 20 off-spec incoming oil drives the pistons. Only the separate authenticated reserve qualifies for delivery. Each original 44 m^3 lot is held for two hours. Samples and references can all mislead, and a breach on the way to the buyer can spoil a lot that passed upstream.

What the register counts

A positive-pressure water curtain can limit oil outside and still push water inward. Both the exterior oil limit and the delivered-product gate must pass for the same incident.

ASTM D4177 · Representative automatic sampling of liquid petroleum

What changes when the gas loss swaps trains?

Each physical train was run once with 73% of its gas storage accessible and once with 100%. Two pressure-control rules were replayed separately for each assignment. The same two native incident records supplied the train histories.

Test	Measured in simulation
Train A at 73%, train B at 100%	All 40 thermal states satisfied their limits. The pair supplied at least 403.492 m^3/h across 87,840 due minutes, counting both pressure rules. No new volume crossed after a required stop.
Train A at 100%, train B at 73%	All 40 thermal states passed. The independently replayed minimum was 403.492 m^3/h with zero missed due minutes. Both assignments included eight unavailable piston pairs per train.
Independent heat calculation	Refining the time step from 10 s to 2.5 s gave a peak of 116.068°C and 136.258 kPa absolute. The limits are 120°C and 150 kPa. The initial liner is 87°C and the outer boundary is held at 120°C.
Water at the exposed surface	The 16 mm comparison grid gives 1.34757 kPa in each orientation. With 8 mm supports, case 18 on the fully accessible train governs at 2.09922 kPa. The calculation combines the worst motions and pressure disturbances.

Water saturation properties · IAPWS

How much margin does the finer grid buy?

The selected grid supports the dry side of a 96 mm pressure face. Its shorter unsupported span reduces motion transmitted to the exposed water. Redistributing the same steel keeps the modeled gas space, liquid volume and excavation constant.

Test	Measured in simulation
Water pressure in the rated design	Free-surface margin rises from 1.348 to 2.099 kPa. The confined crown gives 2.382 kPa. All 20 cases pass at the specified air pressure, water-film temperature and backing stiffness.
Construction and exterior oil	The model needs 4.387 billion support contacts per train, with 0.298 mm net webs. The added 4,973,317 m² of metal is charged at 0.10 µg/m², adding 0.614 mL to the paired exterior total.
Common loss of support	When four adjacent spans bridge the missing contacts, free-surface margin falls to 0.898 kPa against 1.330 kPa required. The peak stress-to-allowable ratio is 2.706. All twenty fail this comparison.
Temperature and weather	A further 0.2°C rise leaves 1.586 kPa across all 20 cases. A 0.5°C rise or a separate 2.0 kPa drop in atmospheric pressure defeats cases 12, 18 and 19. At the rated temperature the model needs at least 100.556 kPa ambient.
Web thinning	A further 0.15 mm of metal loss leaves 1.935 kPa of water margin. The web buckles at a stress-to-allowable ratio of 1.246, failing the structural check in all twenty cases.

Can the buyer separate a short water pulse?

The original water limit is 1% by volume in each assessed 44 m³ lot. A litre taken at the outlet can reveal a concentrated leak. This illustration compares local exposure with the result for a separate five-minute batch.

Test	Measured in simulation
Five-minute batch transfer	Four 20 m³ cells per buyer, one unavailable. With immediate mixing and no retained water, all 44 flow and pressure combinations delivered at least 401.323 m³/h. The highest batch water content was 0.613%.
Same readings, different product	Both histories carry 70.670 L of water in the batch. Uniform mixing gives 0.420% locally. Concentrating 59.55 mL of incoming water into one litre gives 6.350%. Both histories report the same assay.
Retained water and queued oil	A delayed 100 L water release gives 1.0123% even after complete batch mixing. If its release mechanism keeps running after hour 60, the queue can deliver another 67.249 m³ across both buyers.
Oil-wet membrane	Of 180 ideal pore, viscosity and fouling combinations, 111 supported flow and water rejection at 500 Pa. The strongest ideal water barrier was 0.300 MPa. None held the direct 3.520 MPa water differential. A leak downstream also bypasses the membrane.

Water breakthrough in oil-wet membranes · Scientific Reports

Can matching crude act as the barrier fluid?

Two charged circuits feed previously qualified product oil between the sale passage and its external water guard. A pressure advantage can keep water out while the fluid entering the sale passage still has the commissioned composition.

Test	Measured in simulation
One working supply	With one circuit unavailable and 100 mm² of effective supply opening, the simulated junction holds 19.601 MPa against 16 MPa of water. No reverse water enters in this comparison. The surviving local circuit needs 67.85 L over 72 hours, including the oil used before the trip. Deducting guard oil from delivery gives 400.178 m³/h of original hydrocarbon in the favorable comparison.
Restricted supply at a wet joint	With only 2.5 mm² of effective feed, 80.45 mL enters at one buyer during the initial pulse. A one-litre sample then contains 8.431% water. Assessing the original 44 m³ lot requires accounting for all water reaching that lot.
Inventory and environmental exposure	The design needs 43,612 m³ of separately counted product oil to fill the protective system. A direct opening releases 20.43 mL during initial closure. Added to the selected installation this reaches 1.019148 L before any further losses.
Acceptance evidence	A positive result requires the minimum open supply area at the actual wet joint, independent pressure during closure, and capture at every outer exit. The coupon and storage calculations do not qualify the final buyer or provide new end-to-end passes.

Will the last lot still qualify at hour 72?

Some reserve oil finishes its two-hour assay before the incident, then waits for its turn to move. These trials follow the actual time each lot leaves storage and enters the customer. Each uses the same original oil and debits for retained water, gas moisture and upstream transfer.

Test	Measured in simulation
The final partial delivery	In case 9, train A sells 16.172 m^3 at the end of hour 72. After charging 20 L of retained water and the other modeled sources, only 50.35 L of additional water can reach that portion.
A leak that continues during storage	At the modeled differential pressure the limiting allowance is 0.699 L/h over 72 hours. An effective area of 0.003 mm^2 yields 0.974% water at worst. All 11 operating groups meet the chemistry limits at that area.
Six full-duration services miss	At 0.004 mm^2, 48 portions exceed the limit. Only the five groups ending service at hour 60 still meet it. At 0.10 mm^2, 23,896 of 27,064 portions fail and the worst is 10.149% water.
What decides the outcome	The effective areas represent flow at one specified pressure. They are sensitivity inputs. To close the eleven delivery cases, the model needs an independently supported upper bound on all water reaching the same sold portion and a pressure history that still delivers 400 m^3/h. The customer retrofit must also retain the registered exterior and total-loss performance.

Can the actual buyer run dry?

Each real buyer receives the oil into its original tank. The design drains its water-backed equipment before service and collects the displaced dry nitrogen in weighted gas holders. The oil still crosses the buyer's original inlet. The final partial delivery is scored on the amount sold.

Test	Measured in simulation
Isolated lot and measured water	Across 27,064 replayed full and partial deliveries, 20 L of trapped water and a continuous equivalent opening of 0.10 mm^2 produced at most 0.964% water. All 11 operating cases met the modeled chemistry limits under this condition.
What still fails	A single 100 L pocket of retained wash water caused 48 portions to fail. Only 5 of 11 operating cases then met the chemistry limits. With the original wet opening under liquid-column pressure, 27,064 portions failed. An empty backing circuit still leaves other sources of water.
Acceptance at the buyer	The smallest sold portion was 16.172 m^3. Its unassigned water budget, after charging moisture from both gas inventories, is 70.35 L. The collection test must include all trapped and newly admitted water through the two-hour hold and up to 14 minutes of discharge.
Total loss at the converted receiver	The air-filled enclosed catcher requires 157,335 m^3 per buyer. A fully excavated pair exceeds the remaining cut by 12,688 m^3 before access or lining. Gas storage, tank loads, stop behavior and exterior oil would need to pass on the converted installation.
Mild vacuum at startup	At 90 kPa absolute, each enclosed catcher needs 106,741 m^3. Both fit with a 20% construction allowance and 45,804 m^3 remaining. The shell must carry 11.325 kPa inward initially, local ground loads and 70 kPa outward in the hot-loss calculation. Vacuum retention and external water ingress remain open.

Which lot reaches the buyer?

A physical 44 m^3 cell holds the original reserve for a two-hour quality check. Three one-litre samples represent that cell. Product identity and downstream additions must be traced to the actual buyer for each transfer, including the last partial lot.

Test	Measured in simulation
Original reserve	Each buyer has 334 full indexed lots in the stock calculation. Case 20 drives the pistons with off-spec incoming oil. The sale side must contain only its authenticated original reserve and bounded additions. False samples and references cannot verify a broken separation.
Water, chloride and sediment	Across 27,064 sold portions in 11 operating cases, a two-second high-pressure exposure followed by density head yielded maxima of 0.927 vol% water, 2.982 mg/kg organic chloride and 0.0209 mass% solids. The limits are 1%, 5 mg/kg and 0.05%.
Water while the cell waits	With the wet connection open during the two-hour hold, maximum water rose to 8.242%. Sustained high pressure during discharge alone reached 9.620%. All 11 operating cases fail these alternatives.
A later slug reaches one lot	When 300 L of trapped water displaces oil containing 0.50% water in one 44 m^3 lot, its mean rises to 1.178%. A tank average after the sale cannot certify what crossed the custody boundary earlier.

How much water can the buyer tolerate?

The actual receiver begins with 16,400 m^3 of backing water behind a diaphragm. Its transfer into sold oil is a separate possible source from the upstream guard leaks. The common-tear area and pressure across it remain unbounded in the selected installation.

Test	Measured in simulation
Six cubic metres left in each tank	Six m^3 of the original reserve at each actual buyer limits whole-tank water to 0.840% from the modeled field leaks alone. The starting charge earns zero delivery credit. This alternative needs a prospectively agreed tank assessment and independent protection from the receiver's backing water.
A subdivided water receiver	With 6 million independent water circuits per buyer, fully emptying 32 circuits releases 112.81 L. The model adds 61.94 L of new field water per swept lot. Starting at 0.50%, each 44 m^3 lot tolerates 221.11 L of water substitution.
An obstructed return or a common tear	Only 46.36 L of additional, previously trapped water fits in that lot. A common connection between more circuits defeats the tested limit. The exterior-oil subtotal is already 0.999891 L before the remaining equipment is charged.
What the present register credits	All nine immediate-isolation cases meet their assigned gates. The six 72-hour recoveries and five delayed shutdowns still require a proven transfer of on-spec product at the actual buyer. These separate receiver trials add zero complete cases.

Can a measured stroke or a weigh lock close the gap?

Both devices use the original prequalified inventory once. Each needs a positive cutoff at the actual buyer when delivery must stop.

Test	Measured in simulation
Finite starting stroke	Two 25 L spring-loaded cylinders per buyer were charged with 100 L across the site. With one unavailable per buyer, the surviving cylinder meters 19 L. After a two-second pressure pulse, all 44 operating comparisons delivered at least 400.366 m^3/h of genuine original hydrocarbon.
Sustained inlet or jammed discharge	The same finite stroke gives only 367.392 m^3/h under sustained high pressure. If one active discharge jams open on each side after shutdown, 50 L can cross the closed boundary. A separate physical disconnect is essential.
Matched cassette weights	A proposed mechanical comparator reweighs the actual sealed cargo before release. With oil density at most 900 kg/m^3, the charged whole-batch bound is 0.902% water. At 920 kg/m^3 it is 1.060%. The tighter case requires temperature matching within 0.05 K.
What could defeat the weighing test	An unobserved 100 L return after testing lifts the whole-batch water bound to 1.376%. Weighing cannot resolve dissolved organic chloride independently. Isolation, contamination identity, retained water and the loaded receiver stop require physical qualification.

Which changes could qualify delivery?

Each comparison uses its own stock, pressure boundary and excavation. The listed results belong to that layout. The complete mission decision is on the case register.

Configuration	Result
Move the existing assayed stock	Moving 14,700 m³ per train to the customer and deducting the entire terminal nitrogen pulse gives 400.661 m³/h minimum. All 20 material and stop schedules pass. No additional sale stock is credited.
Low-pressure customer connection	A flywheel and a protected transfer head give 400.175 m³/h in the forward-flow test. A pressure wave at the actual inlet can interrupt delivery. The native customer requires positive liquid pressure throughout the event.
New receiver on the surface	The full-pulse support works and new water and gas would add at least 0.008638 L before all additional customer equipment. One compartment can retain the tested dirty gas and clean carrier at 3.694 MPa.
Buried receiver and rock supports	A 7 m internal radius and three entrances require 666,729 m³ for the two customers before the complete pressure arch and guard fittings. The 4 m gallery and 1,413 physical drives per train leave 69,976 m³ for those additions.

Which changes could qualify delivery?

Each comparison uses its own stock, pressure boundary and excavation. The listed results belong to that layout. The complete mission decision is on the case register.

Configuration	Result
Gas barriers at working fittings	Across the straight panel, one live gas jacket gives 102.56 mm of gas along the limiting cut. A service intersection changes its direction twice. The flat panel alone cannot establish the gas length around an elbow, a hatch or a regulator.
Closed water inventory in a support	A sealed measured charge and a hollow rod give a 68.013 MPa high-side pressure. After new nitrogen and metal are charged, the paired oil reduction in this separate component comparison is 0.001366 L. The selected installation still counts the gross expansion housing.
Reinforced buried receiver	Distributed anchors and a steel pressure arch carry the modeled ground loads. The service head and pressure gear raise the extra local works to 62,954 m³ on top of the two main receivers. A closed curved cap provides 204 mm of gas. A working regulator and the adjoining loaded ring each need a continuous verified boundary.
Divide the actual buyer pool	With 32 of 768 pockets unavailable, 14 mm partitions displace 175.3 m³. The remaining water film is 0.0848 m against the 0.10 m minimum. Usable water-channel area is 46.25 m² against 48 m².

Which changes could qualify delivery?

Each comparison uses its own stock, pressure boundary and excavation. The listed results belong to that layout. The complete mission decision is on the case register.

Configuration	Result
Rupture of the guard supply	Rupturing the entire 3,100 m³ nitrogen source at 38 MPa gives 37.617 MPa in its enclosure. The remaining guard holds 9.30 MPa. The four-metre gallery is short of 25,365 m³ even before excavation for portal frames.
Reduced gallery height and drive count	The 3.5 m route and 1,595 drives per train pass all 80 thermal states, peaking at 117.09°C. They leave 130,647 m³ after the main buyer bores. A complete expanded pressure vessel must fit this volume and the remaining oil budget.
Seam-free diagnostic body	A straight replacement body removes the drilled diagnostic branch. The simulation adds an independent ninth fault in every pickup. The unmodified shared guard cannot protect all 1,152 fault regions. the selected installation retains the original 0.27648 L allowance for its 128 blind instruments.
Rapid release into added expansion space	A 17,378 m³ enclosure settles at 8.859 MPa. In a 560-cell calculation the pressure at the wall peaks at 10.404 MPa after 94.2 ms. The surviving guard holds 9.30 MPa. The larger shell and all its initial fluid also count toward the oil and earthwork limits.

Which changes could qualify delivery?

Each comparison uses its own stock, pressure boundary and excavation. The listed results belong to that layout. The complete mission decision is on the case register.

Configuration	Result
Raise the real buyer operating level	An additional 5,250 m³ of water per buyer gives 0.211 m of water film with 32 cells lost. The compartment can hold the scheduled oil. A water front at the actual wet joint requires 64.18 mm of uninterrupted opposing flow in this model. A 45° defect gives only 5.66 mm in one span. Guarded water transfer remains unbounded.
Smallest independent diagnostic retrofit	Two full gas supplies rupturing at one new diagnostic body can be contained at 3.543 MPa in the static calculation. Each modified site adds more than 24,000 tonnes, and the rapid response at its own foundation remains unproven. The case register claims zero oil savings from removing these branches.
Pressure space, supports and excavation together	The expanded-vessel study compared 1,200 geometry and support combinations. With 35% extra gas space, the highest wall pressure is 8.654 MPa against 9.30 MPa and the rock checks pass. The installation exceeds the excavation limit by 17,636 m³ before the raised buyer works. The minimum paired oil charge is 1.001601 L.

What the excavation buys

The reference installation includes the energy hardware, support bases, pressure circuits and grade works for two trains. The dry receiver has a separate excavation account.

Counted item	Paired cut, m^3
Dry galleries at 5.5 m, blower parcels, process field, vapor and donor equipment	68,813,949
Remote blower shoe substitution on the same parcels	-323,645
Additional rapid-load foundation works across 128 pickups	3,198,205
Independent grade rails and pressure-trim pads	209,510
Additional exterior-capture earthwork	0
Paired total	71,898,018
Allowance remaining	301,982

The 5.5 m choice had the lowest cut in the tested gallery sensitivity with the full original backfill reservation. Retiring the towers releases no additional ballast credit in this estimate. Ports and inclines retain their clearances. A 527×402.5m exposed-grade yard on each pickup, 1mm mean surface preparation. 31×23 independent support groups. All 2.7m+ rock-blade slots, 10% overcut, crosshead hardware and returned old short-socket cut accounted. Region-wide flooding beneath the free wing and complete loss of rock bond fail. Fit/rock/access/works remain site dependent.

Commercial scale

Each of 128 pickups uses 9,600,000 tonnes of tied foundation materials, purchased components and charge, incl crown/receipt and 3,770 tonnes residual trim. Up to 125,000 additional tonnes of protected exterior plant/captured fluid. Independent grade islands priced separately. Steel manufacture, assembly access, clean-water logistics, finite inventory and site area would all govern a commercial decision. Excavation by itself measures only one of these constraints.

Incident cases 1–10

These results apply to the reference installation. Nine immediate-isolation cases pass its full simulation. Eleven remain open. The oil column includes the charged working water for both trains.

Case	Incident	Assigned duty	Exterior L	Full case
1	Source closing energy lost and conventional valves jammed	Stop at onset	0.9981	Pass
2	Terminal closing energy lost and conventional valves jammed	Stop at onset	0.9981	Pass
3	Source and terminal closing energy lost with jammed conventional valves	Stop at onset	0.9981	Pass
4	Trigger inlets blocked with jammed conventional valves	Stop at onset	0.9981	Pass
5	Pilots blocked with jammed conventional valves	Stop at onset	0.9981	Pass
6	Sleeves torn with jammed conventional valves	Stop at onset	0.9981	Pass
7	Sleeve closing force tripled with jammed conventional valves	Stop at onset	0.9981	Pass
8	5 mm^2 seat gaps with jammed conventional valves	Stop at onset	0.9981	Pass
9	Three route boundaries lost	Flow for 72 h	0.9981	Open
10	Independent heat envelope penetrated	Flow for 72 h	0.9981	Open

Reading the register

A flow duty of 40% refers to 400 m^3/h of a 1,000 m^3/h reference. Each required minute is checked. An immediate isolation still owes the full 72-hour containment duty.

Incident cases 11–20

These results apply to the reference installation. Nine immediate-isolation cases pass its full simulation. Eleven remain open. The oil column includes the charged working water for both trains.

Case	Incident	Assigned duty	Exterior L	Full case
11	Closed catch boundary lost	Stop at onset	0.9981	Pass
12	Loaded collapse and outer-vault loss at 60 h	Flow to hour 60	0.9987	Open
13	100 mm source-gas wall breach	Flow for 72 h	0.9981	Open
14	Gas heat transfer degraded	Flow for 72 h	0.9981	Open
15	Catch heat transfer reduced at 60 h	Flow to hour 60	0.9981	Open
16	Local pocket outer boundary lost	Flow for 72 h	0.9981	Open
17	Catch heat transfer lost at 60 h	Flow to hour 60	0.9981	Open
18	Enclosure gas starts at 86°C	Flow to hour 60	0.9987	Open
19	Catcher shield fully open	Flow to hour 60	0.9987	Open
20	All current quality evidence falsified	Flow for 72 h	0.9981	Open

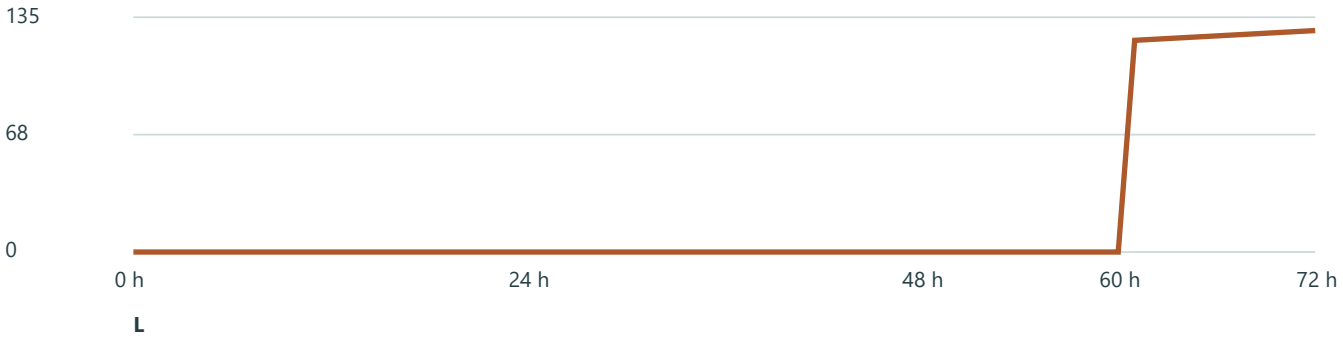
Reading the register

A flow duty of 40% refers to 400 m^3/h of a 1,000 m^3/h reference. Each required minute is checked. An immediate isolation still owes the full 72-hour containment duty.

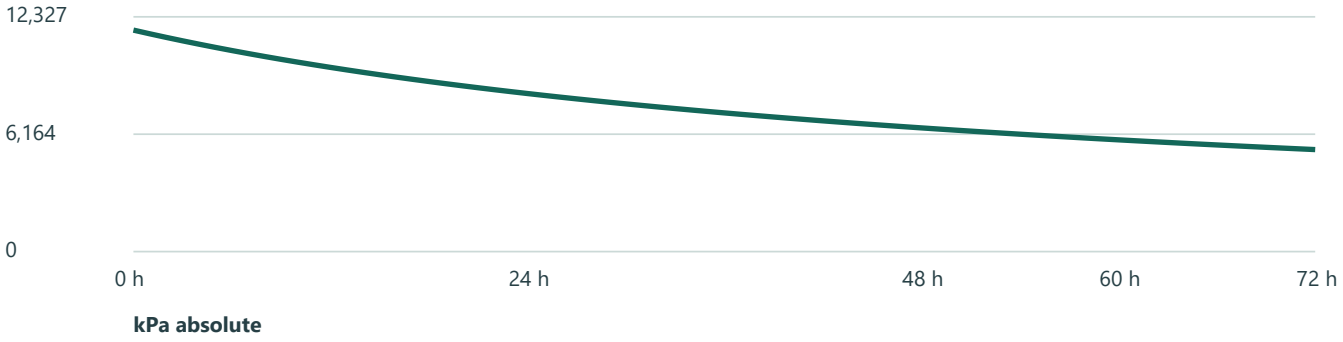
When case 12 loses its receiver

Case 12 calls for reserve oil deliveries through hour 60. Loss of the loaded endpoint then changes what the spill and vapor systems must hold. These two reference-installation traces use the same registered clock.

Paired bypass oil caught inside the protection



Local guard pressure at the receiver



At hour 72, the outer circuit has intercepted 127.403 L of routed bypass oil across both trains. Its local working pressure is 5,356.1 kPa absolute. Oil captured in a blind receiver remains on site. The total assigned exterior charge for this case is 0.998720 L.

> **Residual risk**
>
> The pressure and custody records can look satisfactory while an independent through-opening carries oil to the environment. The common-opening control in the incident panel quantifies that consequence.

Successful and failed trials

Each row names the modeled condition and its actual consequence. Adverse controls remain visible alongside the rated cases.

Condition	Observed result
Guarded bypass under rated duty	The paired charge reaches 0.998720 L. This includes 0.081461 L in auxiliary water and surface residues, and 0.066700 L in auxiliary nitrogen at 1 ppt condensable hydrocarbons as toluene equivalent. Guard fill requires ≤0.005 µg/L and clean metal ≤0.10 µg/m². The 8 mm dry support grid adds 0.000614 L of surface residue to the exterior account.
Bypass through every barrier	A one-part-per-million continuous path to the environment reaches 128.383 L. A separate common-bore control reaches 14.142 L.
Rapid pressure rise	23/23 rated foundation traces met the charged support criteria including two carbon-steel protection-bent outages, two of four dashpots unavailable, and rerouted grade caps and rails. Maximum 1.879 MPa ground, 344.4 MPa blade, 0.36642 MPa grout. Independent failure of half the gas in every foot gives 165.6°C vs 160°C.
Grade motion during delivery	With the guarded dock installed, all 20 pressure clocks pass. The least actuator headroom is 1,240.7 Pa. The 8 mm dry support grid gives 2.09922 kPa above saturation at the exposed water surface and 2.38245 kPa at the confined crown. The combined ground reaction reaches 1.89326 MPa against 2 MPa.
One vapor circuit receives all guard water	All 20 case clocks stay inside the 120°C and 70 kPa gauge limits. The refined donor reaches 117.48°C and the refined catcher 114.20°C. Loss of segregation of the water exits sends the donor to 122.10°C.
Blower shaft seized	0 of 80 thermal states pass the locked-shaft comparison. Containment and product credit require the actual blower startup and heat rejection.

Successful and failed trials

Each row names the modeled condition and its actual consequence. Adverse controls remain visible alongside the rated cases.

Condition	Observed result
Guard circuits at their rated defects	20/20 exterior component checks. Upper component charge 0.84595 L
One ppm through every layer	0/20 exterior component checks. Upper component charge 128.23008 L
One open bore across the installation	0/20 exterior component checks. Upper component charge 13.98897 L
Commissioning water without final polishing	0/20 exterior component checks. Upper component charge 1.04902 L
Residue and free grease	0/20 exterior component checks. Upper component charge 1.74156 L
Both receiver lifts jammed	0/20 exterior component checks. Upper component charge 56104.91243 L

Successful and failed trials

Each row names the modeled condition and its actual consequence. Adverse controls remain visible alongside the rated cases.

Condition	Observed result
Both equalization routes blocked	5/20 exterior component checks. Upper component charge 5901762.69203 L
Hot guard with no condensation	0/20 exterior component checks. Upper component charge 5901762.69203 L
Large oil jet across the water layer	0/20 exterior component checks. Upper component charge 112081.61332 L
Half the gas lost in every support	The support gas reaches 166.3°C against a 160°C limit in the loss-of-charge control. The rated foundation instead carries its specified precharge, lost seats and disabled dampers through the signed load tests.
Five-metre gallery with tower fill released	Removing the retired tower fill demand but reserving full new shoe backfill leaves 459,624 m³ for additional customer works. Blower and gas residues increase by 0.000364 L. All 80 thermal states pass. This option requires measured usable spoil.
one sealed mask and one pilot unavailable	400.3945 m³/h lower-bound genuine crude in first due minute. 13.961 m³ possible inward utility water over 72h. wet mechanical screen True

Successful and failed trials

Each row names the modeled condition and its actual consequence. Adverse controls remain visible alongside the rated cases.

Condition	Observed result
both independent masks jam at one hole	395.8031 m^3/h lower-bound genuine crude in first due minute. 344.541 m^3 possible inward utility water over 72h. wet mechanical screen False
uncollapsed narrow bypass across both seats	392.6470 m^3/h lower-bound genuine crude in first due minute. 570.605 m^3 possible inward utility water over 72h. wet mechanical screen True
both pilot paths defeated	Zero guaranteed genuine crude in the first due minute (signed inventory balance -4301.1909 m^3/h). 338528.110 m^3 possible inward utility water over 72h. wet mechanical screen False
long tear reaches the deployed replacement	Zero guaranteed genuine crude in the first due minute (signed inventory balance -4301.1909 m^3/h). 338528.110 m^3 possible inward utility water over 72h. wet mechanical screen False
hot interspace and both dry relief paths blocked	400.3945 m^3/h lower-bound genuine crude in first due minute. 13.961 m^3 possible inward utility water over 72h. wet mechanical screen False
unbalanced curtain pressure on the slide	Zero guaranteed genuine crude in the first due minute (signed inventory balance -4333.3099 m^3/h). 338528.563 m^3 possible inward utility water over 72h. wet mechanical screen False

Successful and failed trials

Each row names the modeled condition and its actual consequence. Adverse controls remain visible alongside the rated cases.

Condition	Observed result
two fully overlapping incidents	399.2338 m^3/h lower-bound genuine crude in first due minute. 13.977 m^3 possible inward utility water over 72h. wet mechanical screen True
differential trips late and metering plunger has large stroke	399.5692 m^3/h lower-bound genuine crude in first due minute. 13.973 m^3 possible inward utility water over 72h. wet mechanical screen True
Dry nitrogen in all vulnerable sale galleries	Liquid front stops in 72.71 mm of 79.8 mm. Initial gas can displace 2.232 m^3. Unseparated first minute gives 267.84 m^3/h genuine oil.
Three-metre dry gap and moving overlap	One aligned cut clears the jet. Two separate cuts can realign after 29.01s. The retained 72h tape weighs 29,698t per pickup. Splash and joint integrity remain open.
Twin-wall virgin liner pulled after damage	An isolated 590mm line takes 4.720 h to pull, charge and prove. The modeled clean startup stock is 948.1 m^3/train. Terminal joins, hidden double liner holes and physical hot-seat integrity remain open.
Existing clean reserve moved to the two customers	The original 14,699.93 m^3 per train is counted once. All 20 volume and stop schedules pass at 400.661 m^3/h minimum in service. That volume is previously assayed stock. The local gas, custody and containment tests decide whether it can be credited.

Successful and failed trials

Each row names the modeled condition and its actual consequence. Adverse controls remain visible alongside the rated cases.

Condition	Observed result
Preparation under the remote blowers	The aboveground shoes save 323,645 m^3 on exposed rock. If the same pad pockets require another 0.80 m of removal, the paired installation reaches 72,350,319 m^3.
Trace oil in auxiliary water	Filling the blowers, rails and foundation dashpots at 0.050 µg/L increases the largest combined charge to 1.5483 L. The model charges the entire initial water and separate surface inventory.
Auxiliary nitrogen at ten parts per trillion	Charging all auxiliary gas inventory at ten times the assigned condensable hydrocarbon content gives up to 1.59902 L across both trains. The assumed installed cleanliness must be verified after filling.

What would establish safe service

No integrated physical demonstration or surveyed site forms part of this study. The acceptance test must reproduce the loads used to decide the numerical cases.

Measurement	Required evidence
Support and motion	Apply a signed pressure history on the two sheet faces. Measure contact force and loss, joint stroke, local bed motion and takeoff elevation on a common clock. Include the tested outages and eccentricities.
Oil and vapor	Use tracers in every charged source. Capture all exits in independent weighed receivers and quantify extraction and blank uncertainty. Reproduce a common bypass and the total-loss event at hour 60.
Continuity and quality	Maintain at least 400 reference m^3/h every due minute with eight pairs down per train. Verify product identity independently and prove zero new custody after each required stop.
Energy and site	Measure precharge and remaining useful stroke, full blower startup and 72-hour work. Survey bearing stiffness, shear, the grade alignment and bank-to-compacted material yield before accepting excavation quantities.

Release decision

The combined installation completes 0 of 20 modeled missions. Qualification requires a verified stop under hidden receiver loss, measured oil, vapor and water crossing actual boundaries, and confirmation of thermal and civil margins at the installed equipment. The reference installation completes 9 immediate-stop missions and the dry-receiver comparison completes 0.