THE UNDERGROUND FAMILY

CS-460

THE CARRIER THAT RIDES EXISTING LINE

A module-train carrier sized to the bore that rides pipe, culvert and conduit already in the ground, on the flow, on its own drive or on a tether.

CS-460 is the Underground family's carrier for line that already exists. It takes the form, the discs and the launcher-and-receiver handling of pipeline pigging and builds them out as a train of short modules carrying a sensing or service payload. The flow already in the line moves it, or its own drive, or a tether. It never bores.

~150–600 mm
BODY DIAMETER, NOMINAL BORE CLASSES

Up to ~20 km
FLOW-DRIVEN LOGGED RUN, CLASS-DEPENDENT

Up to ~0.8 m/s
UNDER ITS OWN POWER

~8–15 kg
MODULAR PAYLOAD BAY, ~10 L

~700 kPa
SEALING DISCS, NOMINAL LINE-PRESSURE DESIGN CASE

AT A GLANCE

A CARRIER FOR LINE ALREADY IN THE GROUND. IT NEVER TOUCHES A BIT TO SOIL.

Five figures size the carrier. Four reasons explain why an operator sends it down the line instead of opening the ground.

NOTHING IS OPENED

NO CUT, NO SPOIL, NO REINSTATEMENT

It enters at a fitting the line already has and leaves at another. The line stays in service throughout, and the ground above it is never touched.

THREE WAYS THROUGH

THE MODE IS CHOSEN FOR THE LINE

Flow-driven in a live line, self-propelled in a dead one, tethered where the run needs a fixed speed and a hard stop on command. Propulsion, payload and the comms plan are selected before insertion rather than fixed at the factory.

ONE BAY, FOUR CLASSES

INSPECT, EMPLACE, LAY FIBRE, TREAT

A modular bay amidships of ~8–15 kg and ~10 L takes the inspection package as its baseline, and carries sensors, relays, fibre and service fluids through the same interface. Nothing energetic is a permitted payload class.

ESTABLISHED PRACTICE

ROOTED IN A TRADE THE GROUP ALREADY RUNS

The cylindrical form, the sealing discs and the trap handling come from a decades-old industrial tool class, and the group's pipeline practice runs bi-directional pigs for cleaning and gauging today. The carrier is the new engineering; the pigging is not.

IN THIS SHEET

01 · SPECIFICATION

BODY, PROPULSION, SEAL AND BAY. EACH FIGURE BESIDE ITS BASIS.

The product specification and the systems engineering behind it, grouped the way an integration lead reads an in-line carrier: the body family, what it is made of, how it moves, how it seals, what it carries, how it navigates and reports, and how it goes in and comes out.

01 BODY FAMILY

PARAMETER	VALUE	BASIS
Configuration	Cylindrical pipeline and conduit-class carrier with sealing discs and a modular payload bay	the product specification table
Body diameter range	~150–600 mm (~6–24 in) nominal bore classes, disc-set matched	design value, the product specification table
Length	~1.1–1.6 m (class-dependent)	design value, the product specification table
Mass	~35–90 kg (class-dependent)	design value, the product specification table
Architecture	A train of short cylindrical modules on articulated joints	bend passage is governed by the longest rigid element, not by the whole vehicle
Module order, nose to tail	Payload bay · electronics and battery · drive module · tail cup or tether terminus	the module-train layout
Centring	Every module carries its own cups or discs	the train stays centred through fittings
Family scaling	Made per bore size; electronics, payload interface and software common; cups, chassis rings and drive arms scale	the family scaling rule

02 MATERIALS

PARAMETER	VALUE	BASIS
Chassis rings, module shells, joint hardware	Glass-filled nylon	loads are compressive and abrasive rather than aerodynamic
Cups and discs	Cast polyurethane-class elastomer	the pipeline trade's standard pig material for abrasion life; the elastomer is the consumable
Covers, end fairings, training bodies	Recycled PET, non-structural	nothing recycled carries load or seals pressure
Electronics housing	Sealed external-pressure vessel, rated above the line's maximum operating pressure with margin	the vessel is loaded from outside, so the question is stability rather than containment

03 PROPULSION

PARAMETER	VALUE	BASIS
Propulsion modes	Flow-driven · self-propelled · tethered, selected per mission	the product specification table
Flow-driven	Sealing discs ride the pressure differential of a live product flow	the product specification table
Flow-mode speed control	Adjustable bypass port through the body; deployable friction shoe as the brake	the standard speed-control answer in gas service
Self-propelled	Wheels or tracks under its own power, for dry or non-flowing conduits	the product specification table
Self-propelled traction	Spring-loaded arms press the drive wheels to the wall, on guide discs	the crawl-mode mechanism
Tethered	Controlled pull on a fibre-composite umbilical from a surface winch: fixed speed and a hard stop on command, power and comms down the tether	the product specification table and the tethered-mode mechanism
Speed, flow-driven	~0.5–2 m/s, line-speed dependent	design value, the product specification table
Speed, self-propelled	Up to ~0.8 m/s	design value, the product specification table
Run length, flow-driven	Up to ~20 km, logged run (class-dependent)	design value, the product specification table
Run length, tethered	Up to ~5 km (class-dependent)	design value, the product specification table; the bend count also limits a tethered run
Tethered reach limit	Cumulative bend angle: tether tension multiplies exponentially over the bends	the capstan relation; the route survey counts bends before anyone mobilizes

04 SEALS AND PRESSURE

PARAMETER	VALUE	BASIS
Sealing discs	Rated to the line-pressure design case, nominal ~700 kPa (~100 psi)	design value, the product specification table
Flow-mode elastomer set	Dished sealing cups, oversized to the bore	the differential energizes the lip: the harder the line pushes, the tighter the seal
Self-propelled and tethered elastomer set	Flat guide discs, near line-to-line, deliberately non-sealing	centring at a fraction of the drag where no differential exists
Changing mode	Same chassis, different elastomer set	a tooling change rather than a redesign

05 PAYLOAD BAY

PARAMETER	VALUE	BASIS
Payload bay	Amidships, modular: ~8–15 kg / ~10 L	design value, the product specification table
Baseline suite	Inspection package: wall-thickness and corrosion gauging, geometry and deformation mapping, run odometry	the product specification table
Payload classes	Inspect · emplace · lay fibre · treat	one bay, four classes, all non-kinetic
Mechanical interface	Standard module length per bore size · common chassis-ring bolt pattern · common articulation coupling	the bay interface, defined once for every class
Electrical interface	One connector: regulated power · data bus · safety-interlocked actuate line	the bay interface, defined once for every class
Payload class boundary	Non-kinetic only: no warhead, no fuze, no energetic material and no terminal-effect device, in any module	a design exclusion written on the interface

06 NAVIGATION AND COMMS

PARAMETER	VALUE	BASIS
Navigation	One-dimensional: distance along the line	position in a pipe is a single number
Odometry	Spring-loaded odometer wheels, several and voted; the drive wheels in self-propelled mode	the standard in-line inspection method
Drift correction	Girth-weld detection re-zeros the count; a small inertial unit adds attitude and bend detection	passive corrections against the pipe itself
Surface truth	A crew or above-ground markers confirming passage by passive magnetic detection	nothing is emitted to find the carrier
Comms, tethered	Fibre tether: real-time control and data	the product specification table
Comms, untethered	Position and sensor data logged onboard, offloaded at the receiver or exit point	the product specification table
Radio and GNSS	None: no radio, no GPS; pipe and conduit are RF-dead environments by nature	the product specification table

PARAMETER	VALUE	BASIS
Untethered autonomy	A pre-planned script against odometry waypoints; the vehicle cannot roam	a person authorizes every actuate event before insertion

07 LAUNCH, RECOVERY AND OPERATING RULES

PARAMETER	VALUE	BASIS
Launch and receive	Standard pig launcher and receiver-style trap access points	the product specification table
Gauge run	Never enters a line a gauge run has not been through first	an operating rule inherited from the group's pigging practice
Gas service	No emplacement without the tether or the self-propelled mode	a stuck-then-released carrier in gas accelerates violently
Line access	Settled by ownership and permission before any run; counsel first on third-party infrastructure	outside the engineering boundary

08 CLASSIFICATION

PARAMETER	VALUE	BASIS
Munitions classification	Carrier, not a munition: never itself armed, carries nothing energetic	the product specification table
Boring scope	CS-410 and Aquifer CS-411 make the hole; CS-460 never bores	the product specification table
Patent status	Patent pending	the product specification table
Export control	Export-controlled; international transfer subject to Canadian government permits; counsel first	the product specification table

02 · THE PREMISE

MOST OF THE NETWORK IS ALREADY BURIED. THIS CARRIER WORKS INSIDE IT.

Boring is expensive, disruptive and slow, and most of the network a utility, a pipeline operator or a facility needs inspected or serviced is already in the ground and ready to carry a vehicle.

CS-460 sits apart from the rest of the Underground family. Every other platform there enters ground that has to be made, found or opened; this one rides pipe, culvert and conduit that is already open, carrying the sensor or the tool through it without touching soil. CS-410 and Aquifer CS-411 make the hole.

The form comes from a decades-old industrial tool class, the pipeline inspection gauge the trade calls a pig: a cylindrical device run through a live line for cleaning, product batching or inspection. Canadian Shield did not invent that tool class. The carrier keeps its form, its sealing discs and its launcher-and-receiver handling and builds them out for sensing and payload modules rather than one fixed tool.

NO GROUND BROKEN

NO CUT, NO SPOIL

No trench is dug to reach the line or to leave it, and the ground over the run stays as it was.

THE LINE STAYS LIVE

SERVICE CONTINUES

In flow-driven mode the product flow that keeps the line in service is the propulsion, and the run happens inside normal operation.

NOBODY GOES IN

A CONFINED SPACE STAYS EMPTY

It goes where a hazardous, confined space would otherwise mean sending a person in after it. Nothing about it is launched: it is inserted, driven and received.

03 · PROPULSION

LIVE LINE, DEAD LINE, HARD STOP. THREE MODES FROM ONE BODY FAMILY.

A live line gives propulsion away, a dead conduit gives none, and a run that has to stop on command wants a wire.

MODE	HOW IT MOVES	WHERE IT FITS	WHAT LIMITS IT
Flow-driven	Sealing cups take the differential of a live flow; a bypass port bleeds flow past the body to set speed	A live, flowing, trap-equipped line; no onboard propulsion energy	A dead, dry or unserviced conduit has no differential to ride
Self-propelled	Spring-loaded arms press drive wheels to the wall, on guide discs	Dry, low-flow and dead line, culverts and conduits, and wherever stop-and-hold matters	The battery bounds the range
Tethered	Pushed and pulled on a fibre-composite umbilical from a surface winch, with power and comms down the wire	Power, bandwidth and a retrieval that is a pull on a wire	Cumulative bend angle bounds the reach

Flow-driven, the carrier travels at line speed, about 0.5–2 m/s, and a logged run reaches up to about 20 km, class-dependent. Under its own power it moves at up to about 0.8 m/s. A tethered run reaches up to about 5 km, class-dependent, and the bend count on the route limits it as well. Class-dependent figures move with the bore served and the disc set fitted.

04 · THE BODY

SHORT RIGID MODULES ON JOINTS. A BEND MEETS ONE MODULE AT A TIME.

Bend passage is governed by the length-to-diameter ratio of the longest rigid element rather than of the whole vehicle, and that one fact sets the architecture.

The carrier is a train of short cylindrical modules linked by articulated joints of universal or flexible-coupling class, the standard in-line inspection architecture and standard for the same reason. Nose to tail the train runs payload bay, electronics and battery, drive module, then a tail cup or the tether terminus. Every module carries its own cups or discs, so the train stays centred through a fitting instead of dropping a shoulder into it.

A carrier is made per bore size rather than stretched across sizes. The electronics, the payload interface and the software are common across the family; the cups, the chassis rings and the drive arms scale. The family's sizing logic is a crossover: flow-driven thrust grows with bore area, so flow drive gets easier as the pipe gets bigger, while a crawler's battery burden grows with diameter, so self-propulsion favours the small end.

~150–600 mm	~1.1–1.6 m	~35–90 kg
BODY DIAMETER ACROSS THE FAMILY	LENGTH, CLASS-DEPENDENT	MASS, CLASS-DEPENDENT

Sealing cups, for flow drive. Dished elastomer, oversized to the bore, presenting a flexible lip that the differential pressure presses against the wall. The harder the line pushes, the tighter the cup seals, and that is what lets a carrier ride a live line. Cups are also the main source of drag aboard, a cost the line pays for.

Guide discs, for wheels and wire. Flat, near line-to-line and deliberately non-sealing, they centre the carrier at a fraction of the drag. Where no differential exists and every newton of drag is battery or winch load, the carrier keeps its centring and gives up a seal it cannot use.

Changing mode is the same chassis with a different elastomer set: a tooling change rather than a redesign. The sealing discs are rated to the line-pressure design case, nominal about 700 kPa (about 100 psi).

05 · FLOW-DRIVEN

IN A LIVE LINE THE PUSH IS FREE. SPEED IS WHERE THE ENGINEERING GOES.

Driving force is the pressure differential across the sealed face times the area of that face, so available thrust grows with the bore.

In a live line, propulsion costs nothing aboard, and the engineering at this end is speed control. The answer is the standard one from gas service: an adjustable bypass port through the body bleeds flow past the carrier to regulate its speed, with a deployable friction shoe to brake it. A run that reaches the right place at the wrong speed has neither placed its payload nor measured the wall.

Gas service adds a hazard with its own standing rule. The gas column behind a stuck carrier behaves as a spring, and a carrier that sticks and then releases accelerates violently. Nothing is emplaced in gas service without the tether or the self-propelled mode.

OPERATING RULE

NO EMPLACEMENT IN GAS SERVICE WITHOUT THE TETHER OR ITS OWN DRIVE.

In gas service the line sets the speed and a stuck carrier can release violently, so precision work runs on the tether or on the carrier's own drive.

06 · SELF-PROPELLED

A BATTERY BUYS A SHORT LINE. LONG LINES GO TO THE FLOW OR THE TETHER.

On guide discs the drag is mechanical rather than pressure-energized, and the carrier's own pack pays for every metre.

Spring-loaded arms press the drive wheels to the wall, and the wheels give odometry at the same time. Traction is set by that preload, and every newton of preload is also rolling drag, so preload is spent rather than simply applied. Under its own power the carrier moves at up to about 0.8 m/s, and it can stop and hold, which is what emplacement and treatment need.

The battery bounds the run, so the conclusion is a scoping one: the mode serves short, dry and dead line and hands long lines to flow drive or the tether.

- ✓ Dry, low-flow and dead lines, where there is no flow to ride.
- ✓ Culverts and conduits.
- ✓ Any run where the carrier must stop, hold and act at a surveyed point.

07 · TETHERED

COUNT THE BENDS BEFORE MOBILIZING. THE TETHER'S REACH FOLLOWS THEM.

Tether tension multiplies over cumulative bend angle rather than adding up along the length. It is the capstan relation, and it is exponential.

A route with many bends can bring a modest straight-line pull to a large load at the winch, so the route survey decides a tethered run before anyone mobilizes, and the number that matters in it is the bend count rather than the distance. A low-friction jacket and traction assist from the carrier buy margin; neither repeals the exponent. The product specification gives a tethered run of up to about 5 km, class-dependent.

- ✓ Power that does not run out, because it comes down the wire rather than out of a pack.
- ✓ Bandwidth for live video and live control, keeping a person in the loop throughout the run.
- ✓ A retrieval that is a pull on a wire rather than a search, with nothing to jam because nothing on the link is a signal in the air.

The fibre and the payout discipline that manages it are shared with the family's own tether work, so one payout competency serves the boring plant, the tethered mode and the lay-fibre payload.

08 · THE SEALED VOLUME

LOADED FROM OUTSIDE. COOLED ONLY THROUGH THE WALL.

The electronics live inside a line under pressure, and that makes the housing a pressure-vessel problem rather than a gasket.

The housing is rated above the line's maximum operating pressure with margin. It is the reverse of the usual case: the vessel is loaded from outside, so the design question is stability rather than containment. The same sealing that keeps the product out keeps heat in. Battery and motor heat has no airflow to reject into, only conduction to the shell and on to the pipe wall, and that path is the whole thermal design.

The structural life is abrasion, external pressure and bend-cycling fatigue at the joints. With no launch shock, no aerodynamic load and no impact requirement anywhere in the design, the structure is sized against what the pipe does to it.

CHASSIS

GLASS-FILLED NYLON

Chassis rings, module shells and joint hardware. The loads are compressive and abrasive, a materially easier case than any flying structure.

CUPS AND DISCS

POLYURETHANE-CLASS ELASTOMER

The trade's standard pig material for abrasion life, cast at low pressure on moulds the group cuts in its own shop. The elastomer is the consumable, by design.

COVERS AND FAIRINGS

RECYCLED PET, NEVER STRUCTURAL

Non-structural covers, end fairings and training bodies. Nothing recycled carries load or seals pressure.

09 · LAUNCH AND RECOVERY

IN AT A TRAP, OUT AT A RECEIVER. THE RECORD COMES HOME WITH IT.

Handling mirrors the pipeline trade's own pigging practice, because the fittings on a serviced line were built for exactly this operation.

1. **In at the launcher** Inserted at a pig launcher or an equivalent access point, with the payload module fitted and the mode chosen for the line: flow-driven if it is live, self-propelled if it is not, tethered if the run needs a fixed speed and a hard stop.
2. **Along the line** It rides the flow, its own drive or the tether, carrying and sensing the length of the run. Data streams over the fibre where a tether is fitted and is logged aboard where it is not, and the line stays in service.
3. **Out at the receiver** Retrieved at a receiver or exit point, or pulled back on the tether. Logged data comes off at the receiving end, the way an inspection gauge has always come home.

The line itself is the hazard list, and every item on it is a known class with a known answer. Girth-weld root beads, mitred joints, unbarred tees where a cup can dive into a branch, reduced-port valves, dents, ovality, wax, scale and diameter transitions are met with bumper noses, disc spacing that always keeps two supports in the barrel, and a minimum-bore gauging run first. That last is a rule inherited from the group's pigging practice: CS-460 never enters a line a gauge run has not been through.

Whether a given line may be entered at all is not an engineering question. On line an operator owns or holds contracted access to, entry is a commercial fact and a permit to work; on any other infrastructure it is a legal question first, and it goes to counsel before a run is scoped.

10 · NAVIGATION AND THE RECORD

POSITION IS ONE NUMBER. THE PIPE ITSELF CORRECTS IT.

Inside buried steel a radio signal dies and a satellite fix never arrives, so the no-radio doctrine costs nothing to keep here and navigation reduces to distance along the line.

Spring-loaded odometer wheels count distance, and running several and voting between them handles slip, wax films and wheel wear; in self-propelled mode the drive wheels count it as well. Every girth weld is a milepost, and detecting each one re-zeros the accumulated error, so drift is corrected against the pipe rather than left to grow. A small inertial unit adds attitude, bend detection and dead reckoning through a slip. Surface truth is a crew or above-ground markers confirming passage by passive magnetic detection, so nothing is emitted to find the carrier.

TETHERED

LIVE OVER THE FIBRE

Real-time control and data over the fibre tether: live video and live control, with a person in the loop for the length of the run.

UNTETHERED

RECORD AND RETURN

Position and sensor data are logged aboard and offloaded at the receiver or exit point. The record comes out of the trap with the carrier, and no radio link exists in any mode.

An untethered run executes a pre-planned script against odometry waypoints: travel, sense, act at a surveyed point, continue, be received. It is the narrowest autonomy in the fleet. The carrier cannot roam, and a person authorizes every actuate event before it is inserted.

11 · THE PAYLOAD BAY

ONE INTERFACE, FOUR PAYLOAD CLASSES. EVERY ONE OF THEM NON-KINETIC.

The bay sits amidships at ~8–15 kg and ~10 L, and its interface is defined once, so a new payload is a tooling change rather than a new vehicle.

INSPECT

THE BASELINE SUITE

Wall-thickness and corrosion gauging, geometry and deformation mapping and run odometry, with camera, laser profilometry, leak and gas sensing, and pressure and temperature logging on the same bay.

EMPLACE

AT A SURVEYED WAYPOINT

Sets down a seismic or acoustic node, a relay or a marker at a surveyed point, through a bay door and an ejector commanded at an odometry waypoint.

LAY FIBRE

FROM AN ONBOARD SPOOL

Pays out optical fibre as the carrier travels, the family's fibre-conduit work carried through pipe that already exists.

TREAT

AT A LOCATED DEFECT

Discharges internal sealant, corrosion inhibitor or repair material at a defect an inspection run found, from a tank through a pump and valve set to an applicator ring.

Mechanically the interface is a standard module length for each bore size, a common chassis-ring bolt pattern and a common articulation coupling. Electrically it is one connector carrying regulated power, a data bus and a safety-interlocked actuate line. Wall-thickness sensing is where a carrier has to be exact about what it buys: magnetic flux leakage is the industry workhorse and its magnet and yoke mass weighs on the bay budget, conventional ultrasonics need a liquid couplant, which suits a liquid line and not a gas one, and electromagnetic acoustic transducers work without one. Canadian Shield builds the carrier and partners the sensing physics.

DOCTRINE

A CARRIER, NEVER ARMED. THE EXCLUSION IS WRITTEN ON THE INTERFACE.

The bay volume and the actuate line are engineered for sensors, relays, fibre and service fluids. No warhead, no fuze, no energetic material and no terminal-effect device is a permitted payload class, in any module, for any customer.

12 · CONFIGURATIONS

ONE BODY FAMILY, MADE PER BORE. THE MODE IS CHOSEN FOR EACH RUN.

What changes between the builds is the elastomer set, the drive module and the tail, and every build shares the electronics, the payload interface and the software.

FLOW-DRIVEN

SEALING CUPS, BYPASS PORT AND BRAKE

For a live, flowing, trap-equipped line. The flow is the propulsion, the bypass port sets the speed, the friction shoe brakes, and a logged run reaches up to ~20 km, class-dependent.

SELF-PROPELLED

GUIDE DISCS, TRACTION ARMS AND A BATTERY

For dry, low-flow and dead lines, culverts and conduits, and any run that must stop and hold. Up to ~0.8 m/s, with the drive wheels doubling as odometry.

TETHERED

GUIDE DISCS AND A TETHER TERMINUS

For runs that need live control, a fixed speed, a hard stop on command and a retrieval by pull. Power and comms come down a fibre-composite umbilical from a surface winch.

PER BORE SIZE

COMMON CORE, SCALED RING

Made across nominal bore classes of ~150–600 mm with the disc set matched to the bore. Cups, chassis rings and drive arms scale; the electronics, the payload interface and the software stay common.

13 · DOCTRINE AND SAFETY

A CARRIER WITH NOTHING ENERGETIC ABOARD. NOTHING ON ITS LINK CROSSES THE AIR.

The lines that hold in every mode, in every module and for every customer.

- ✓ Carriers, not munitions: CS-460 carries a payload module and is never itself armed. No warhead, no fuze, no energetic material and no terminal-effect device is a permitted payload class, in any module, for any customer.
- ✓ No radio and no GPS in any mode: tethered runs talk over fibre, untethered runs log aboard and return the record at the receiver, and surface truth is passive magnetic detection.
- ✓ Human safety comes first, on every line. A live line is a confined space nobody should have to enter, a person authorizes every actuate event before insertion, and nothing is emplaced in gas service without the tether or the self-propelled mode.
- ✓ Entry to a line is settled by ownership and permission before any engineering, and on third-party infrastructure it goes to counsel first.

THE CONVERSATION

BRING THE BORE, THE PRODUCT AND THE BENDS. THE MODE AND THE DISC SET FOLLOW.

A first conversation needs the bore class, the product in the line, the operating pressure, the bend count and the traps the line already has.

Start a screened enquiry at cdnshield.ca/enquiries.

DOCUMENT	CDN-PROD-SPC-015 · CS-460 · Specification sheet
REVISION	R1.0 · issued 2026-09-10
WEB VERSION	cdnshield.ca/systems/underground/spec-sheets/cs-460 · carries the current revision
RELATED SHEETS	CS-410 · Aquifer CS-411 · CS-425 · CS-430 · Trembler Line CS-435
ISSUED BY	Canadian Shield · cdnshield.ca