MAINTAINABILITY ANALYSIS

Faster Repairs on Critical Assets: Where the Repair Time Goes

A repair-time element study of the seven highest-impact repair tasks on Line 3 and homogenizer HG-1, with levers ranked by return and a maintainability standard for new equipment.

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CLIENT	Larkspur Valley Foods, Inc. — Plant 2 (cultured dairy)
SCOPE	7 repair tasks on tier A assets: HG-1, P-310, seal heads, indexing chain, GR-305, denester
REPORT NO.	MA-2026-006 · Revision 0 · Issued December 18, 2026
METHOD	Elapsed-time breakdown into eight repair elements from observed repairs, CMMS records, and trial repairs with improved methods (IEC 60300-3-10:2025; IEC 60706-3:2006)
RELATED WORK	Failure rates are taken after the RCA-2026-014, FMECA-2026-007, and ROI-2026-005 actions, so no benefit is double counted

Demonstration document. Sample report. All company names, people, data, and financial figures are fictional and shown for demonstration only. The structure, methods, and level of detail match Apex Reliability Engineering client deliverables.

Executive Summary

Decision brief for the Plant Manager and Plant Controller. Sections 1–6 contain the supporting detail.

BOTTOM LINE

Only **34% of repair time on these tasks is hands-on work**. The rest is diagnosis, lockout, fetching parts, access, and restart. One finding matters most: the HG-1 planned seal change takes 3.6 h against a 3.0 h sanitation window. That costs a hidden **$15.6K/yr**, which ROI-2026-005 assumed was zero. A **$13.0K** package fixes it, pays back in about 8 months, and is positive in every scenario. The other three levers are deferred because they do not pay at today's lower failure rates.

HANDS-ON SHARE OF REPAIR TIME	HG-1 CHANGE VS. WINDOW	HIDDEN OVERRUN COST	RECOMMENDED SPEND	L1 NPV, 5 YR
34%	**3.6 / 3.0 h**	**$15.6K/yr**	**$13.0K**	**$58K**
Weighted by task frequency	2.35 h with the L1 package	$96K PV over the ROI's 10 years	of $42.5K identified	$20K conservative

DECISIONS REQUESTED

1. **Fund L1, the HG-1 set-change package** ($12,996): lifting fixture, torque multiplier, pre-staged kit, group LOTO, standard work.
2. **Convert P-310 to a cartridge seal at its next failure** (L2). It is break-even as a stand-alone project and positive when done with a repair already planned.
3. **Adopt the design-for-maintainability standard** (Section 6) for all new equipment and major modifications.

WHAT THE ANALYSIS SHOWS

- FINDING Parts and tools logistics alone is 17% of repair time, the largest non-repair element.
- FINDING The ROI case for HG-1 holds only if its planned changes fit the sanitation window. Today they do not.
- JUDGMENT Earlier actions have already cut failure rates, so repair-speed projects must now clear a higher bar. Three of four do not, yet.

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1 Scope and Method

Maintainability is how quickly and safely an asset can be restored. It is measured here as elapsed time per repair, broken into the elements a planner can actually change.

TABLE 1.1 — TASKS STUDIED

ID	ASSET · TASK	PER YR	ELAPSED NOW	$/DOWNTIME H	FREQUENCY SOURCE
T1	**HG-1 homogenizer** · Valve and seal set change (planned)	4.00	3.60 h	$6,500	ROI-2026-005 (1,500 h interval)
T1u	**HG-1 homogenizer** · Valve and seal set change (unplanned)	0.32	4.00 h	$6,500	ROI-2026-005 residual
T2	**P-310 product pump** · Mechanical seal replacement	1.05	3.50 h	$2,615	FMECA FM-01 residual
T3	**Line 3 seal heads** · Heater cartridge replacement	1.00	1.20 h	$2,615	FMECA FM-11 residual
T4	**Line 3 indexing chain** · Chain replacement and timing	0.45	5.00 h	$2,615	FMECA FM-14 residual
T5	**GR-305 filler drive** · Gear reducer change (spare on hand)	0.27	10.50 h	$2,615	RCA-2026-014 residual
T6	**Line 3 denester** · Vacuum cup replacement	3.60	0.40 h	$2,615	FMECA FM-09 residual

Frequencies are residual rates *after* earlier actions. T1 is planned, so only time beyond the sanitation window costs production. HG-1 downtime is valued at $6,500/h because it idles every filling line; Line 3 uses the blended $2,615/h from FMECA-2026-007.

TABLE 1.2 — REPAIR ELEMENTS

CODE	ELEMENT	WHAT IT COVERS
D	Diagnose	From call to known cause and part
L	Permit and LOTO	Permits, isolation, verification of zero energy
P	Parts and tools logistics	Finding, fetching, and waiting for parts, tools, and lifting gear
A	Access and disassembly	Guards, covers, and components removed to reach the failed part
R	Repair or replace	The hands-on fix
S	Reassemble and adjust	Reassembly, alignment, torque, timing, tension
Q	Sanitation and QA release	Re-cleaning after the intervention and food-safety release
T	Test and restart	Functional test and return to production

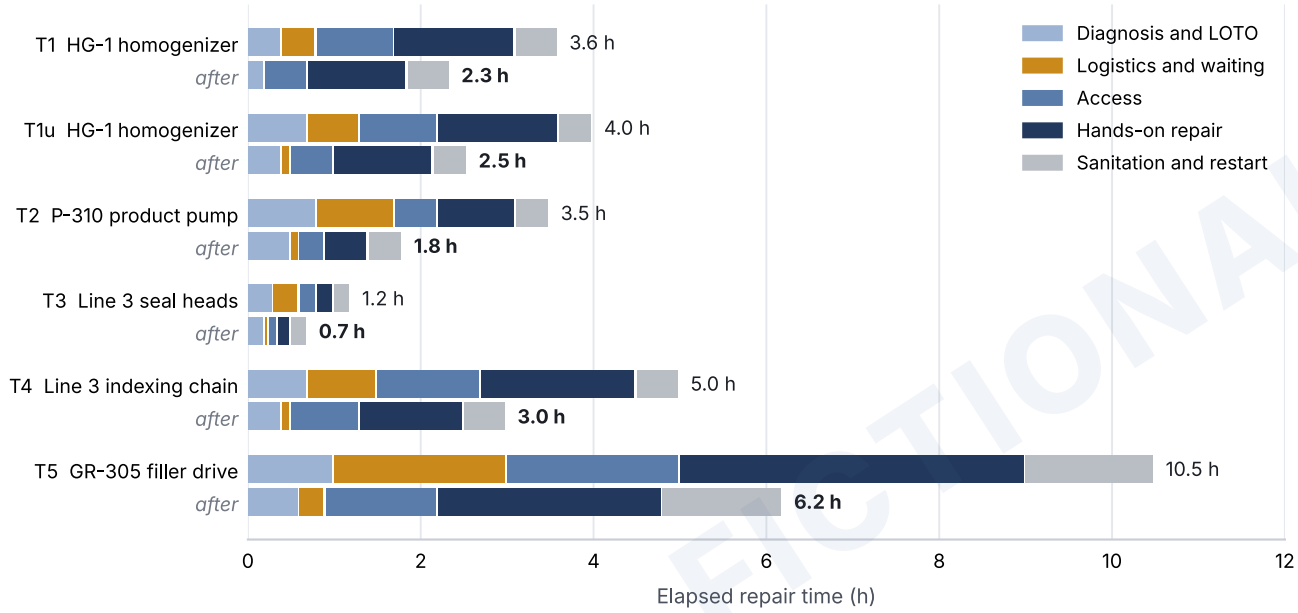
Baselines come from 21 observed repairs and CMMS timestamps. Improved times come from trial repairs using the proposed methods and tooling.

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2 Where the Repair Time Goes

Across these tasks, 27.1 h a year of elapsed repair time would drop to 16.7 h. Nearly all of the cut comes from elements other than the hands-on repair.

FIGURE 2.1 — ELAPSED REPAIR TIME BY ELEMENT, NOW AND AFTER IMPROVEMENT



T6 (denester cups, 0.4 h) is omitted for scale. Its figures are in the Appendix.

TABLE 2.1 — ANNUAL ELAPSED REPAIR HOURS BY ELEMENT (FREQUENCY-WEIGHTED)

ELEMENT	D	L	P	A	R	S	Q	T	TOTAL
Now	1.1	2.8	4.5	5.9	5.2	4.1	2.8	0.8	**27.1**
After	0.8	1.5	0.3	3.5	4.6	2.5	2.8	0.7	**16.7**

WHY THIS MATTERS BEYOND THESE TASKS

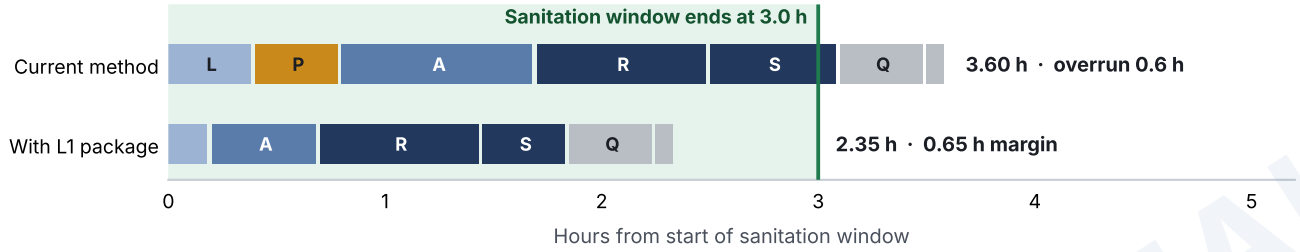
Logistics, access, and lockout delays are system problems: kitting, storeroom location, guard design, and LOTO practice. Fixing them once shortens every future repair, including failures nobody has predicted.

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3 The HG-1 Sanitation-Window Finding

ROI-2026-005 recommends changing HG-1's valve and seal set every 1,500 h, inside a sanitation window, at no production cost. Timing the task showed that the assumption does not hold yet.

FIGURE 3.1 — HG-1 PLANNED SET CHANGE AGAINST THE SANITATION WINDOW



Segments are labeled by element code (Table 1.2). L1 removes the parts fetch (P), halves access time with a lifting fixture, and shortens LOTO and reassembly.

TABLE 3.1 — HG-1 PLANNED CHANGE, ELEMENT TIMES (H)

ELEMENT	NOW	WITH L1
L · Permit and LOTO	0.40	0.20
P · Parts and tools logistics	0.40	0.00
A · Access and disassembly	0.90	0.50
R · Repair or replace	0.80	0.75
S · Reassemble and adjust	0.60	0.40
Q · Sanitation and QA release	0.40	0.40
T · Test and restart	0.10	0.10
Total	**3.60**	**2.35**

EFFECT ON ROI-2026-005

Each planned change overruns the window by 0.6 h. At four changes a year and $6,500/h, that is **$15,600/yr**, or $95,855 of present value over the ROI's 10-year horizon. The ROI's recommendation still holds, but only with L1 in place. Without it, the ROI overstates O1 and O2 by that amount.

MARGIN AFTER L1

2.35 h leaves 0.65 h of margin for the occasional seized fastener or extra QA check, so the gain does not depend on everything going right.

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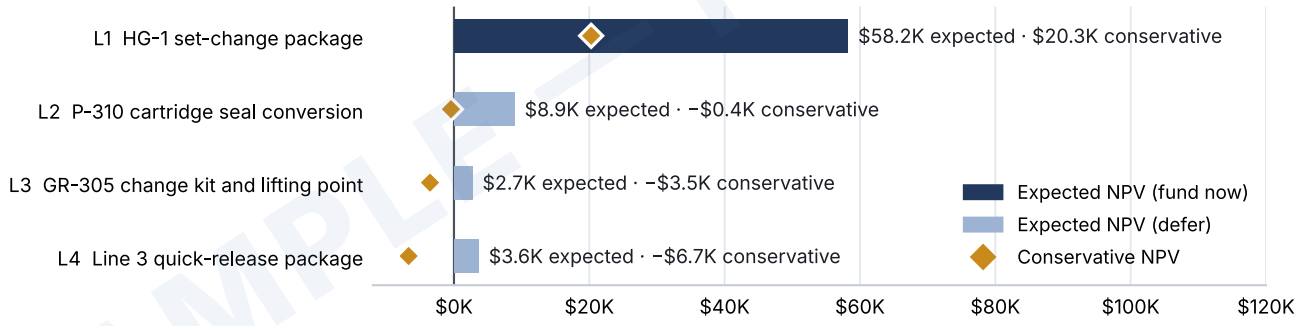
4 Improvement Levers

Four packages were costed and tested in trial repairs. Each is judged on its own, because each has to earn its place.

TABLE 4.1 — LEVERS AND THEIR ECONOMICS (5-YEAR, 10% HURDLE RATE)

ID	LEVER	WHAT IT INCLUDES	COST	BENEFIT/YR	PAYBACK	DECISION
L1	**HG-1 set-change package** Tasks T1, T1u	Valve-block lifting fixture, torque multiplier, pre-staged kit, group LOTO, standard work	$12,996	$19,442	8.3 mo	FUND NOW
L2	**P-310 cartridge seal conversion** Tasks T2	Cartridge seal adapter, point-of-use seal stock, LOTO and standard work	$7,748	$4,794	21.1 mo	ON NEXT FAILURE
L3	**GR-305 change kit and lifting point** Tasks T5	Trolley lifting point, kitted torque-arm hardware, alignment card	$7,948	$3,214	33.9 mo	DEFER
L4	**Line 3 quick-release package** Tasks T3, T4, T6	Quick-release guards, heater quick-disconnects, chain timing marks, point-of-use stock	$13,796	$5,295	36.0 mo	DEFER

FIGURE 4.1 — NPV BY LEVER, EXPECTED AND CONSERVATIVE



WHY DEFER GOOD ENGINEERING

L3 and L4 make repairs faster and safer, but those repairs are now rare, because RCA-2026-014 and FMECA-2026-007 cut their frequency. At today's rates they lose money in the conservative case. They go into the design-for-maintainability standard (Section 6), so new equipment arrives with these features at little extra cost.

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5 Financial Justification

The recommendation is to fund L1 now. The full package is shown alongside it so the decision to defer is visible.

TABLE 5.1 — INVESTMENT BY LEVER AND ACCOUNTING TREATMENT

ITEM	CLASS	AMOUNT	TREATMENT
Point-of-use spares cabinets and task kits (Line 3, HG-1)	CAPEX	$6,200	Tooling and fixtures; capitalize if above plant threshold (Controller review)
HG-1 valve-block lifting fixture and torque multiplier	CAPEX	$7,800	Tooling and fixtures; capitalize if above plant threshold (Controller review)
P-310 cartridge seal conversion (adapter + first seal)	CAPEX	$4,600	Tooling and fixtures; capitalize if above plant threshold (Controller review)
Quick-release guards and quick-disconnects (filler, chain, heaters)	CAPEX	$8,900	Tooling and fixtures; capitalize if above plant threshold (Controller review)
GR-305 lifting trolley point and pre-kitted mounting hardware	CAPEX	$5,400	Tooling and fixtures; capitalize if above plant threshold (Controller review)
Group LOTO lockbox stations and verified procedures	OPEX	$2,100	Expensed as incurred
Standard work, visual aids, timing marks; training (96 h)	OPEX	$7,488	Expensed as incurred
Full package		**$42,488**	
Recommended now (L1)		**$12,996**	**Allocation of the items above; see Table 4.1**
Recurring: refresher training and kit replenishment	OPEX/YR	$2,148	Full package; $657 for L1

TABLE 5.2 — SCENARIO ANALYSIS (PRE-TAX, 5-YEAR HORIZON, 10% HURDLE RATE)

	CONSERVATIVE	EXPECTED	HIGH IMPACT
L1 only (recommended): NPV	**$20,276**	**$58,214**	**$75,834**
Full package: annual benefit	$15,885	$32,745	$40,583
Full package: payback (months)	37.1	16.7	13.3
Full package: NPV	$9,586	$73,499	$103,211
Value of deferring L2–L4 (L1 NPV − full NPV)	**$10,690**	**−$15,285**	**−$27,377**

Conservative: 60% of measured time savings sustained; downtime rates 20% lower. **Expected:** Time savings as demonstrated in trial repairs; downtime rates as stated. **High impact:** Time savings as demonstrated; downtime rates 25% higher (lost volume not recovered). A positive bottom line means funding L1 alone beats funding everything.

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5 Financial Justification (continued)

L1 pays back quickly in every scenario. The full package depends heavily on L1, which is the clearest argument for funding L1 alone.

FIGURE 5.1 — CUMULATIVE NET CASH POSITION, L1 PACKAGE (UNDISCOUNTED)

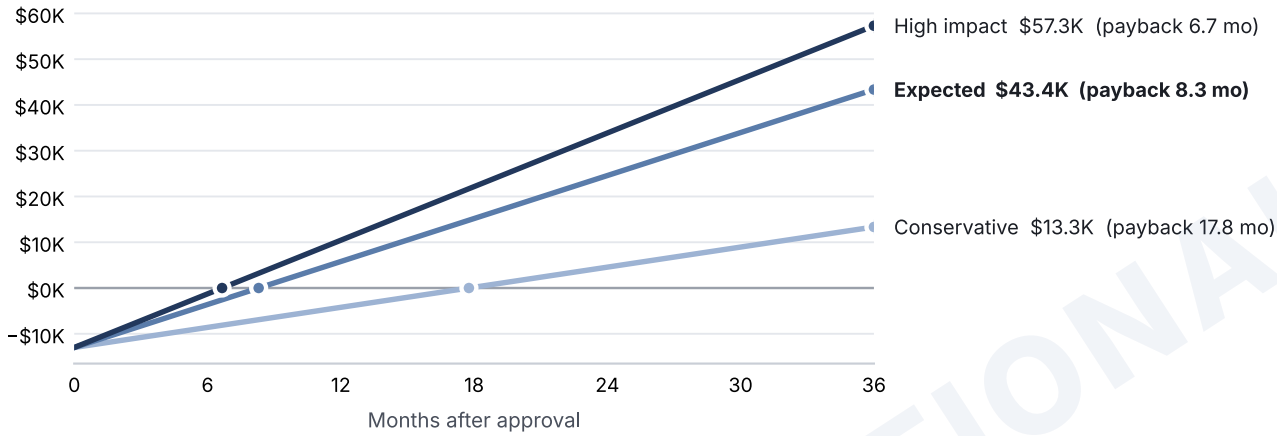


TABLE 5.3 — STRESS TESTS ON THE FULL PACKAGE (CONSERVATIVE)

STRESS APPLIED	5-YEAR NPV
Base case (Conservative)	**$9,586**
HG-1 window fix fails (no T1 benefit)	−$20,536
Investment +40%	−$7,409
Time savings halved again	−$20,524
Discount rate 15%	$3,561

Without the HG-1 fix, the full package loses money. T1 alone supplies 50% of the full package's benefit.

BREAK-EVEN

The full package breaks even if 41% of its measured benefit is realized. L1 alone breaks even well below that, because it carries 50% of the benefit for 31% of the cost.

CONSERVATISM IN THESE FIGURES

Benefits use failure rates *after* earlier actions, and the hidden HG-1 overrun is valued only at the planned-change frequency. Safety and ergonomic gains from lifting aids and group LOTO are real but are not valued.

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6 Design-for-Maintainability Standard, Implementation, and Verification

The cheapest maintainability is designed in. These requirements go into every equipment specification and are verified at factory acceptance.

TABLE 6.1 — MAINTAINABILITY REQUIREMENTS FOR NEW EQUIPMENT (VERIFIED AT FAT/SAT)

#	REQUIREMENT	VERIFICATION
1	Wear parts reachable in ≤ 15 min without special tools	Timed demonstration at FAT
2	Lifting points or fixtures for any component over 23 kg (50 lb)	Drawing review; demonstration
3	Interlocked, tool-less guards on routine-access areas, with hygienic design	Inspection; QA sign-off
4	Cartridge seals and quick-disconnects where the duty allows	Specification review
5	Diagnostics to the failed component (HMI fault messages, LED status)	Fault-insertion test
6	Grouped, labeled isolation points; machine-specific LOTO procedure supplied	LOTO walk-down at SAT
7	Torque values, timing marks, and alignment references marked on the equipment	Inspection
8	Recommended spares list with lead times; task kits for planned work	Document review
9	Demonstrated MTTR for the top 3 expected repairs, stated in the contract	Timed demonstration at FAT

TABLE 6.2 — IMPLEMENTATION AND VERIFICATION

WHEN	ACTION AND MEASURE	OWNER
Weeks 0–6	Build and stage HG-1 kits; install the lifting fixture; issue standard work; train both crews	Planner · Reliability
First 4 changes	Time every HG-1 set change. **Target: ≤ 3.0 h, every time.**	Reliability Engineer
Next P-310 failure	Convert to cartridge seal (L2); time the repair against the 1.8 h target	Maintenance Supervisor
Annually	Re-run L3/L4 economics against actual failure rates; fund if conservative NPV turns positive	Reliability · Controller

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A Element Data, Limitations, References, and Approval

TABLE A.1 — ELEMENT TIMES BY TASK, NOW → AFTER (HOURS)

TASK	D	L	P	A	R	S	Q	T	TOTAL
T1	0 → 0	0.4 → 0.2	0.4 → 0	0.9 → 0.5	0.8 → 0.75	0.6 → 0.4	0.4 → 0.4	0.1 → 0.1	**3.60 → 2.35**
T1u	0.3 → 0.2	0.4 → 0.2	0.6 → 0.1	0.9 → 0.5	0.8 → 0.75	0.6 → 0.4	0.3 → 0.3	0.1 → 0.1	**4.00 → 2.55**
T2	0.4 → 0.3	0.4 → 0.2	0.9 → 0.1	0.5 → 0.3	0.5 → 0.3	0.4 → 0.2	0.3 → 0.3	0.1 → 0.1	**3.50 → 1.80**
T3	0.1 → 0.1	0.2 → 0.1	0.3 → 0.05	0.2 → 0.1	0.1 → 0.1	0.1 → 0.05	0.15 → 0.15	0.05 → 0.05	**1.20 → 0.70**
T4	0.3 → 0.2	0.4 → 0.2	0.8 → 0.1	1.2 → 0.8	0.9 → 0.7	0.9 → 0.5	0.4 → 0.4	0.1 → 0.1	**5.00 → 3.00**
T5	0.5 → 0.3	0.5 → 0.3	2 → 0.3	2 → 1.3	2 → 1.6	2 → 1	1 → 1	0.5 → 0.4	**10.50 → 6.20**
T6	0.05 → 0.05	0.05 → 0.05	0.15 → 0	0.05 → 0.05	0.05 → 0.05	0 → 0	0.05 → 0.05	0 → 0	**0.40 → 0.25**

TABLE A.2 — LIMITATIONS

GAP	EFFECT
Improved times come from trial repairs, not sustained practice ESTIMATE	The conservative case assumes 60% of the savings are sustained
Small sample (21 observed repairs)	Element times are indicative; HG-1 timing is verified over its first 4 changes
Residual failure rates depend on earlier actions being delivered	If they slip, failure rates rise and the deferred levers become more valuable

TABLE A.3 — STANDARDS AND REFERENCES

REFERENCE	TITLE AND USE
IEC 60300-3-10:2025	Dependability management — Part 3-10: Application guide — Maintainability and maintenance. Maintainability programme and measures.
IEC 60706-2:2006	Maintainability of equipment — Part 2: Maintainability requirements and studies during the design and development phase. Basis for the Section 6 standard.
IEC 60706-3:2006	Maintainability of equipment — Part 3: Verification and collection, analysis and presentation of data. Element time collection and FAT verification.
ROI-2026-005 · FMECA-2026-007 · RCA-2026-014	Prior Apex analyses at Plant 2. Residual failure rates and downtime values.

REVIEW AND APPROVAL

Prepared by
Lead Reliability Engineer, Apex Reliability Engineering — Signature — Date

Approved by
Plant Manager — Signature — Date

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