



FK-5-1-12 Clean Agent System

Part 1: What Is FK-5-1-12?

Introduction Series · what it is, how it works, where we use it, strengths and limits

PART

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of 6

1 What it is

2 Safety & environment

3 Components

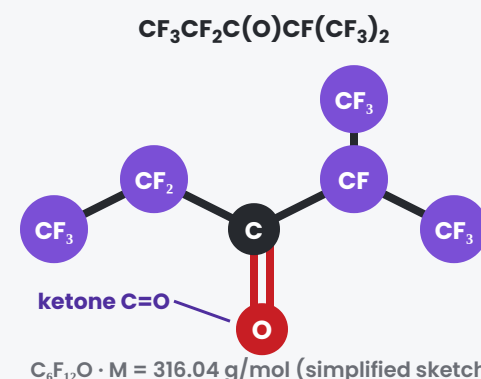
4 Design

5 Install

6 Maintain

1 What Is FK-5-1-12? NFPA 2001 · ISO 14520-5

- A **fluoroketone** clean agent: **dodecafluoro-2-methylpentan-3-one**, $C_6F_{12}O$. “FK-5-1-12” is its generic designation in NFPA 2001 and ISO 14520-5
- A clear, colourless **liquid at room temperature**: it boils at **49.2 °C** and has a vapour pressure of only about **0.33 bar abs** at 20 °C
- Stored as a liquid in cylinders **superpressurised with nitrogen**, which pushes it out through the pipe (Part 3)
- The nozzles break it into fine droplets that **vaporise** within seconds, so the room fills with a gas. We design for about **4.5–5.9 %** by volume (Part 4)
- Electrically **non-conductive**, leaves **no residue**, and its vapour is about **11× heavier than air**



BOILING POINT

49.2 °C

liquid in storage

LIQUID DENSITY

1.6 kg/L

saturated, about 25 °C

DESIGN RANGE

4.5–5.9 %

vol. in air, by hazard

NOAEL

10 %

wide safety margin

DISCHARGE

≤ 10 s

NFPA 2001, halocarbons

2 How It Puts a Fire Out

- Mainly by **heat absorption**: the agent soaks up heat from the flame until the flame is too cool to keep burning
- A smaller **chemical** effect also helps break the flame’s chain reaction
- It does **not** work by removing oxygen: at 4.5 % the room still has about **20.0 % O_2**
- It reaches its design concentration in about **10 s**, so it knocks down a fire while the fire is still small



WHY SO LITTLE AGENT?

A few per cent of a heavy, high-heat-capacity gas cools the flame. Inert gases need roughly **35–45 %** to dilute the oxygen instead.

3 Where We Use It

Data & server rooms

racks, UPS, raised-floor voids

Telecom & control rooms

switch rooms, SCADA, BMS

Electrical rooms

LV switchgear, MCC, battery rooms*

Archives & museums

records, heritage, libraries

Medical & lab

imaging rooms, instruments

Machinery & process

enclosed equipment, turbines*

*Only where the listing and a hazard review support it. NFPA 2001 4.2.2: not on chemicals that carry their own oxygen (e.g. cellulose nitrate), reactive metals, metal hydrides or self-decomposing chemicals, unless tested to the satisfaction of the AHJ.

4 Advantages

- Low design concentration: **compact** storage, few cylinders, small floor area
- Design 4.5–5.9 % against a **10 % NOAEL**: suits normally occupied rooms
- **Fast** 10 s discharge: quick knockdown, fewer decomposition products
- **No residue**, non-conductive: safe for electronics and records
- **ODP 0, GWP about 1**, atmospheric lifetime about 5 days (Part 2)
- Bulk agent is a liquid, so it can be handled **unpressurised** before charging

5 Limitations

- Like every halocarbon, it forms **HF** in contact with fire (Part 2)
- Needs a **tight room**: the heavy gas leaks out low down. Hold time is checked with a door-fan test (Part 5)
- Two-phase flow: **shorter** pipe runs than inert gases, listed software only
- Discharge causes a **negative, then positive** pressure swing, so we check venting
- Deep-seated fires need specific tests; live hazards above **480 V** need a hazard analysis
- **PFAS rules** are changing in some regions (Part 2)



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Part 2: Safety & Environment

Introduction Series · NOAEL margin, environmental data, HF and PFAS regulation trends

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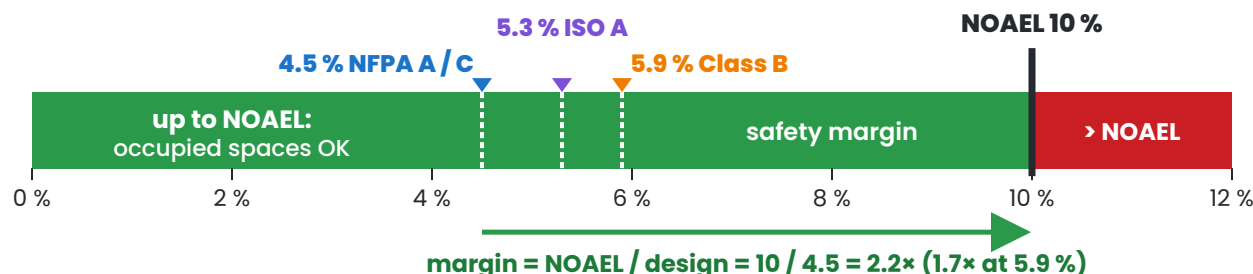
4 Design

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6 Maintain

1 People Safety: Design Concentration vs NOAEL

NFPA 2001 (2025) 4.3.2



Values from NFPA 2001 (2025) Table 4.3.2.4(a). Our 200 m³ room reaches at most 4.8 % at 30 °C (Part 4), a 2.1× margin.

- Systems designed **up to the NOAEL** are permitted in normally occupied spaces
- Even so, **avoid unnecessary exposure**, also below the NOAEL
- Means to limit exposure to **no more than 5 minutes**
- No unprotected entry **during or after** a discharge until the room is ventilated

2 Environmental Profile

OZONE DEPLETION (ODP)

0

no chlorine or bromine

GLOBAL WARMING (GWP)

≈ 1

100-year basis, CO₂ = 1

ATMOSPHERIC LIFETIME

≈ 5 days

broken down by sunlight

AGENT RECOVERY

Recycle

NFPA 2001 11.3.3

GWP and lifetime as published in agent technical data (GWP quoted as ≤ 1; lifetime about 5 days, other studies about 1 week). Agent removed during service is recovered and recycled or disposed of under local law.

3 Decomposition Products

NFPA 2001 Annex A

- In contact with flame or very hot surfaces, FK-5-1-12 breaks down, mainly into **hydrogen fluoride (HF)**, as all fluorinated halocarbons do
- HF is an **irritant and corrosive**: to people and, at higher levels, to electronics
- How much forms depends on **fire size** at discharge, **discharge time**, concentration and how long the fire burns in the agent

✓ HOW WE KEEP HF LOW

- Early detection**: discharge while the fire is small
- 10 s** discharge and the full design concentration
- Shut down power and HVAC on release where the design calls for it
- Ventilate** before re-entry; no entry while fumes remain

4 PFAS Regulation Trends: Where Things Stand (Oct 2026)

neutral summary

- FK-5-1-12 is fully fluorinated, so it falls within **broad PFAS definitions** such as the OECD (2021) one
- EU**: the REACH “universal” PFAS restriction proposal (2023, updated Aug 2025) covers **clean fire suppressants**. The update proposes **derogations**, e.g. for maintenance and refilling of existing systems and some critical uses
- ECHA’s risk committee adopted its opinion in March 2026; the socio-economic opinion and the Commission’s decision are **still pending**. Nothing is final yet
- The EU’s separate 2025 restriction on PFAS in **firefighting foams** does not cover gaseous agents

⚠ WHAT WE DO ON PROJECTS

- Check **local rules** and the client’s ESG policy at the concept stage
- Confirm long-term **agent supply and recharge** with the supplier
- Compare alternatives (inert gas, water mist) where the risk allows
- Keep the agent **contained**: tight rooms, good maintenance, recovery



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Part 3: System Components

Introduction Series · cylinders, nitrogen pressure, valves, pipe, nozzles and release panel

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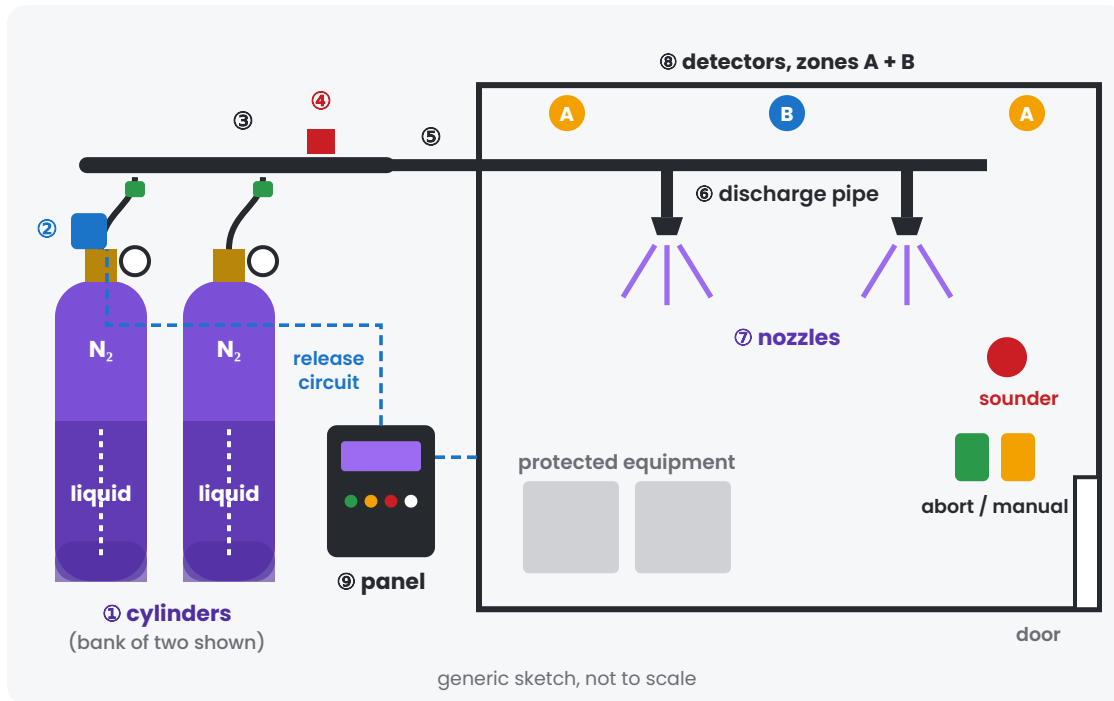
3 Components

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1 System Overview



2 Components

#	Item	What it does
①	Storage cylinders	Welded or seamless steel, sized by agent mass; liquid agent + nitrogen head space; gauge, nameplate, fill data
②	Valve & actuators	Fast-opening cylinder valve; electric (solenoid), pneumatic or manual actuator; removing an electric actuator must show an impairment
③	Hose & check valve	Flexible discharge hose to the manifold; check valve lets one cylinder be removed
④	Pressure switch	Signals 'agent released'; required where a mechanical manual release is used
⑤	Manifold	Joins several cylinders; safety relief on closed sections; selector valves only if listed
⑥	Discharge pipe	Rated at least for the minimum piping design pressure (table); sizes from listed software
⑦	Nozzles	180° / 360°, drilled orifices; listed coverage and height
⑧	Detection	Usually two zones (A + B), point or aspirating detectors
⑨	Release panel	Listed releasing panel, compatible with the actuators; alarms, delay, abort, manual release

3 Nitrogen Superpressurisation NFPA 2001 Table 5.2.1.1.1(b)

Charging pressure at 21 °C	Max. fill, kg/m³	Pressure at 55 °C, bar	Min. piping design, bar
25 bar	1,442	28	25
34 bar	1,201	40	34
42 bar	1,442	48	42
60 bar	1,121	67	60

Selected FK-5-1-12 rows (the table also lists 10 and 13 bar). ISO 14520-5:2024 covers nominal 25, 34.5, 42 and 50 bar. The listed system sets the pressure, fill range and temperature range.

WHY ADD NITROGEN?

- The agent's own vapour pressure is tiny (about **0.33 bar abs** at 20 °C), so it cannot push itself out
- Nitrogen on top drives the **liquid** through the pipe in about 10 s
- **25 bar**: compact single-room systems. **42 / 50 bar**: longer runs, more nozzles, central banks

4 Valves & Actuation NFPA 2001 Ch. 9

- Panel output fires the **solenoid**. Other cylinders follow by pilot pressure or their own actuators
- **Manual** release on the panel circuit, plus a mechanical lever at the cylinder
- The panel must supervise the actuators and wiring; pneumatic lines must be protected

5 Cylinder Location

- Close to the room, often **inside** it for single-room systems, if the listing allows
- Within the **listed temperature range**, out of sun and heat
- Bracketed to the wall or floor, gauge visible, room to **weigh** and swap



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Part 4: Design Basics

Introduction Series · flooding equation, design concentrations, worked example, altitude

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1 f(x) The Halocarbon Flooding Equation

NFPA 2001 Eq. 7.3.1 · ISO 14520-5

AGENT MASS FOR A DESIGN CONCENTRATION

$$W = (V / S) \times [C / (100 - C)]$$

W = agent, kg · V = net volume, m³ (gross minus solid structure) · C = design concentration, vol % · S = specific volume of the vapour at 1.013 bar and the **minimum** room temperature, m³/kg

SPECIFIC VOLUME OF FK-5-1-12 (SI)

$$S = 0.0664 + 0.0002741 \times T$$

T in °C. ISO 14520-5 rounds k₂ to 0.000274. At 20 °C, S = 0.0719

CHECK: CONCENTRATION REACHED

$$C = 100 \cdot (WS/V) / (WS/V + 1)$$

At the min. **and** max. temperature (NFPA 7.3.1.1)

2 Minimum Design Concentrations

NFPA 2001 Annex A · ISO 14520-5

Basis	MDC	kg/m ³ at 20 °C	Our 200 m ³ room
NFPA 2001 Class A (annex)	4.50 %	0.656	131.1 kg
NFPA 2001 Class C (annex)	4.50 %	0.656	131.1 kg
NFPA 2001 Class B, heptane 4.5 x 1.3	5.85 %	0.864	172.9 kg
ISO 14520-5 Surface Class A	5.30 %	0.779	155.7 kg
ISO 14520-5 Higher-hazard Class A	5.60 %	0.825	165.1 kg
ISO 14520-5 Class B heptane	5.90 %	0.872	174.5 kg

NFPA: Class A MEC 3.3 % × 1.2 = 4.0 %, but not below heptane 4.5 %; Class C = 3.3 % × 1.35 ≈ 4.5 %; Class B = cup-burner value × 1.3. ISO: PMMA 4.1 % × 1.3 = 5.3 %. Annex values are informative: the **listed** system value governs.

DISCHARGE & HOLD

≤ 10 s · ≥ 10 min

95 % of the agent for the MDC out of the nozzles within **10 s** (NFPA 7.5.1.1). Then hold **85 % of the MDC** at the highest protected content for **10 min** (7.4.1)

TEMPERATURE

Colder room = denser vapour = **more** agent. Our room: 10 °C → **136.3**, 20 °C → **131.1**, 30 °C → **126.3 kg**

3 Worked Example: 200 m³ Electrical Room (NFPA 2001, Class C)

checked with our Python script

Step	What we do	Result
1	Net volume 10 × 8 × 2.5 m (no voids, nothing deducted)	V = 200 m³
2	Class C (energised electrical, ≤ 480 V), annex value	C = 4.5 %
3	Min. room temperature 20 °C: S = 0.0664 + 0.0002741 × 20	S = 0.071882
4	W = (200 / 0.071882) × (4.5 / 95.5)	W = 131.1 kg
5	Fill rounded up to a practical charge (our assumption)	135 kg
6	Actual C with 135 kg at 20 °C / 30 °C	4.63 / 4.80 %
7	Max. 4.80 % < NOAEL 10 %: fine for an occupied room	margin 2.1×

OTHER NUMBERS WE GET

Min. flow: 0.95 × 131.1 / 10 s = **12.5 kg/s**
Hold target: 0.85 × 4.5 = **3.82 %** for 10 min
Liquid volume: 135 kg / 1.6 = **84 L**
Container: at 1,442 kg/m³ max. fill, ≥ **94 L**

Container size, fill and nozzles come from the listed manual and software. This is a teaching example only.

4 Altitude Correction

NFPA 2001 Table 7.3.3.3

Altitude, m	0	300	610	915	1,220	1,520	1,830	2,440	3,050
Factor	1.00	0.96	0.93	0.89	0.86	0.82	0.78	0.72	0.66

Equivalent altitude, selected rows (below sea level the factor is above 1.00). Applied where pressure differs from sea level by more than 11 % (≈ 915 m).

OUR ROOM AT 1,520 M?

131.1 kg × 0.82 = **107.5 kg**. Thinner air: less agent for the same vol %.



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Part 5: Install & Commission

Introduction Series · flow calculation, nozzles, room integrity, release, tests and handover

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1 Pipe Limits & Flow Calculation NFPA 2001 6.2 · Annex A

- Nitrogen-driven liquid turns into a **two-phase** flow in the pipe. Hand calculation is not practical: we use the **listed** flow software only
- The software sizes the pipe and nozzle orifices and predicts **discharge time**, nozzle pressures and agent per nozzle
- We stay inside its **listed limits**, typically: minimum nozzle pressure, tee split ratios and orientation, pipe volume against agent volume, elevation change, arrival and run-out time differences
- Any change to the route on site = **re-run** the calculation

ACCURACY THE LISTING PROVES

Annex guidance for verifying a flow method: discharge time within **±1 s** (halocarbons) and average nozzle pressures within **±10 %** of the prediction.

NOZZLE PLACEMENT

Listed **coverage area**, **height** and distance from walls; voids get their **own** nozzles; no splashing of liquids; secure light ceiling tiles and loose items.

2 Room Integrity NFPA 2001 7.4 · Annexes D, E

- The heavy vapour leaks out **low**; air comes in **high**. The agent/air interface falls
- **Door-fan test** gives the leakage area and predicts the hold time
- Seal penetrations; doors self-closing; dampers close on release
- **Pressure relief** where needed: the discharge gives a **negative**, then **positive** pressure swing against the room's strength

3 Abort & Manual Release NFPA 2001 9.3, 9.6, 9.7

- **Pre-discharge alarm + time delay** so people can leave
- **Abort** (if fitted): inside the room near the exit, **hold-to-operate**, distinct signal
- **Manual release** overrides the abort; accessible at all times; at least one ≤ 1.2 m above the floor; ≤ 178 N pull
- Manual devices **labelled** with the hazard they protect

4 Labelling

- Warning sign at every entrance and inside: **clean agent protected area**, evacuate on alarm
- 'Agent released, do not enter' indication at the door
- Cylinder labels: agent, mass, pressure, serial and test date; signs to local rules

5 Commissioning Tests NFPA 2001 (2025) Ch. 10

Test	What passes	Clause
Pipe pressure test	Closed circuit, nitrogen / dry gas, at least 2.76 bar (40 psi) ; ≥ 80 % left after 10 min	10.4.14
Flow test	Nitrogen or inert gas through the network: flow is continuous at every nozzle	10.4.15
Enclosure integrity	Door-fan test: predicted hold time ≥ 10 min	10.5, Annex D
Release circuit	Each container release mechanism disabled or replaced by a test device first	10.7.1.4
Functional test	Every detector circuit, manual release, abort; alarms and delay as designed	10.7.2
Interfaces	Fan coastdown, damper closure, power shutdown, remote signals	10.2.3.7, 10.6.6
Agent quantity	Weight of agent in each container verified by weighing or approved method	10.2.3.5

6 Handover

As-built drawings
isometrics, nozzle schedule

Flow calculation
final listed-software report

Integrity report
door-fan, hold time

Test records
pipe, flow, functional

Cause & effect
panel configuration

O&M manual
listing data, spares

Training
operators and room users

Acceptance
signed report, AHJ

A full discharge test is **not** needed to prove the hold time; only where the spec or AHJ asks. Actuators go back on last, the panel goes to **AUTO**, and staff who work in the room are trained on agent safety (10.9.2).



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Part 6: Inspection & Maintenance

Introduction Series · NFPA 2001 schedule, weight and pressure limits, room reviews, agent comparison

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1 Inspection & Maintenance Schedule NFPA 2001 (2025) Chapter 11

When	Who	What we check
Monthly	Owner / trained person	Visual (11.2): panel powered, no trouble or alarm; manual controls clear; no damage; gauges in range; hazard unchanged; old faults fixed. Record kept
Semi-annual	Service technician	Weigh each container and read its pressure (11.3). Refill or replace if agent loss > 5 % or temperature-adjusted pressure loss > 10 %. Tag: date, person, agent, gross / net weight, pressure & temperature
Annual	Qualified service	Inspect, service and test for operation; no discharge test (11.4). Service report to the owner. All hoses examined . Room inspected for integrity changes (or a documented administrative programme)
5-yearly	Qualified service	Hoses tested or replaced (11.7). Containers in continuous service: full external visual inspection (11.6.2)
When due	Approved facility	Container requalification per the regulator (11.6.1); for halocarbon containers this may be a complete visual inspection

2 Our Room: Semi-Annual Limits

NET AGENT
135 kg
as filled (Part 4)

REFILL BELOW
128.25 kg
loss > 5 % = 6.75 kg

25 BAR SYSTEM
< 22.5 bar
temp.-adjusted = refill

Pressure rises with temperature (25 bar at 21 °C is about 28 bar at 55 °C), so we always correct with the manufacturer's chart before deciding. Gauges are checked against a calibrated device. Recovered agent is recycled, never vented.

3 Room Integrity Reviews

- Any new hole through the enclosure is **sealed at once**, keeping the fire rating (11.5.4)
- Changes to walls, ceilings, doors or HVAC: **repeat the door-fan test**
- Changed use or contents: **review the design**

4 FK-5-1-12 vs IG-55 vs CO₂ at a Glance

	FK-5-1-12	IG-55	CO ₂
Standard	NFPA 2001 · ISO 14520-5	NFPA 2001 · ISO 14520-14	NFPA 12 (2025) · ISO 6183
How it works	Mainly heat absorption	O ₂ dilution (N ₂ + Ar)	O ₂ dilution + cooling
Typical design conc.	4.5–5.9 %	37.9–42.7 % (NFPA A / C)	≥ 34 % (surface fires)
Discharge time	≤ 10 s	≤ 60 s (B) / 120 s (A, C)	1 min (surface fires)
Storage	Liquid + N ₂ , 25 / 42 bar typ.	Gas, 200 / 300 bar	Liquid, ≈ 58 bar or low-pressure ≈ 21 bar at -18 °C
Occupied rooms	Yes, up to the 10 % NOAEL	Yes, within O ₂ / time limits	No for new systems, rare exceptions
Space & pipe	Very compact, short runs	Many cylinders, long runs, vents	Compact, lethal at design level
Environment	ODP 0, GWP ≈ 1; PFAS scrutiny	ODP 0, GWP 0	ODP 0, GWP 1

Typical values for comparison only. CO₂: NFPA 12 (2025) bans new total-flooding systems in normally occupied enclosures except in limited cases; deep-seated fires need higher levels and longer times. Always design to the listed system.

5 Safety While Servicing

- Isolate the release (actuators **off**, panel isolated) before any work; tell the occupants
- Disconnected cylinders get their **outlet caps** on; never move a cylinder with the actuator fitted

6 Impairments & Records NFPA 2001 Ch. 12

- Out of service or discharged: **tag** it, tell the owner and the AHJ, restore fast
- Keep every tag, report and test record; they back up the next service