

# CWI — API 1104 (Pipeline) Study & Cheat Sheet

For Certified Welding Inspector candidates on the **API 1104** ("Welding of Pipelines and Related Facilities") code-book path — the pipeline alternative to AWS D1.1 (structural). Part B and the code-book portion are **open book**, so the skill tested is **finding and applying** the right acceptance criterion fast in *your* specified edition. Numbers below are framework-level and marked "verify vs. your edition." · [voltexam.com/cwi-exam-prep](http://voltexam.com/cwi-exam-prep)

**Current edition (as of 2026):** API 1104, **22nd Edition (2021)**, including published Errata (2023). AWS/API specifies the exact edition for your exam date — confirm it on your application and study/sit with that **same** edition. Acceptance figures and even some variable classifications shift between editions.

## 1. The Exam & Part B (Practical) — What's Actually Tested

|                                            |                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Three parts</b>                         | CWI certification is <b>Part A</b> (fundamentals, closed book), <b>Part B</b> (practical / hands-on, open book on a supplied Book of Specifications), and <b>Part C</b> (code application, open book on the code you selected — here, API 1104).                                                                                                                        |
| <b>Part B is open book</b>                 | Part B uses AWS-supplied equipment plus a replica <b>Book of Specifications (BOS)</b> and a Book of Exhibits. You evaluate the acceptability of specimens and documents for procedure qualification, welder qualification, and production welding — using gauges, visual inspection, and the documents provided. Typically ~46 items tied to those hands-on activities. |
| <b>BOS is a code replica, not the code</b> | The BOS contains <b>representative</b> requirements (Structural, Pipeline, and Pressure-Piping style) so the exam can be administered without the copyrighted code. It mimics the structure of a real code (incl. API-1104-style pipeline acceptance) — the tested skill is <b>locating and applying</b> the criterion, not recalling it.                               |
| <b>Plate / replica inspection</b>          | The hands-on portion uses molded plastic <b>replicas</b> of weld specimens plus measuring tools (fillet gauge, undercut/depth gauge, hi-lo, calipers). You measure real features on the replica and judge them against the supplied criteria — measurement discipline and gauge reading matter as much as code lookup.                                                  |
| <b>Part C = your code</b>                  | Part C is where API 1104 (or D1.1, D1.5, ASME IX, etc.) is applied directly. If you selected API 1104, you bring and use API 1104. <b>Master navigating the book</b> — tabs, table numbers, and where each acceptance limit lives.                                                                                                                                      |

## 2. API 1104 vs. AWS D1.1 — Don't Study the Wrong Book

|                                  |                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>API 1104 (pipeline)</b>       | API standard for welding oil & gas <b>pipelines and related facilities</b> (line pipe, gathering, distribution). Covers procedure & welder qualification, production welding, and acceptance of welds by visual and NDE methods. This is the sheet's subject.                                                                                      |
| <b>AWS D1.1 (structural)</b>     | <b>AWS Structural Welding Code — Steel</b> : buildings, bridges, frames. <b>Different book, different acceptance criteria, different qualification rules, different discontinuity treatment</b> . D1.1 study will not prepare you for an API 1104 exam.                                                                                            |
| <b>Key structural difference</b> | API 1104 judges most volumetric/planar discontinuities by <b>type + individual size + cumulative length</b> in a defined weld length (and can fail on accumulation even when each flaw passes alone). It also offers a second, fitness-for-service acceptance route (Annex A). D1.1 uses different logic. Learn 1104's framework on its own terms. |
| <b>Confirm your selection</b>    | You pick the Part C code book on your application. Studying the wrong book is the most common self-inflicted failure. If you meant structural, you want D1.1; if pipeline, API 1104.                                                                                                                                                               |

## 3. Essential vs. Nonessential Variables (Procedure & Welder Qualification)

An **essential variable** is one whose change **requires requalification** (it can affect weld soundness or mechanical properties). A **nonessential variable** can change without requalifying. The two qualification schemes have **different** essential-variable lists — procedure qualification lives in the procedure-qualification section (historically Sec. 5), welder qualification in the welder-qualification section (historically Sec. 6). **Confirm the exact list and section numbers in your edition** before relying on any item.

### 3a. Procedure (WPS/PQR) qualification — commonly-cited **ESSENTIAL** variables

|                        |                                                                                                                                               |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Welding process</b> | A change in welding process, or method of application of a process.                                                                           |
| <b>Base material</b>   | A change in base-material grouping, typically by SMYS bands (e.g. ≤42 ksi; >42 to <65 ksi; ≥65 ksi). Confirm the exact bands in your edition. |

|                             |                                                                                                                                                                                                                                       |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Joint design</b>         | A material change in joint design (e.g. groove type V→U, bevel, root spacing/face) as defined by the code.                                                                                                                            |
| <b>Position</b>             | A change in position (e.g. roll ↔ fixed), or a change from one position group to another.                                                                                                                                             |
| <b>Wall thickness group</b> | Moving between wall-thickness groups (commonly <4.8 mm / 3/16 in; 4.8–19.1 mm; >19.1 mm / 3/4 in). Confirm exact breakpoints in your edition.                                                                                         |
| <b>Filler metal group</b>   | A change between filler-metal groups; for higher-strength base metal (≥65 ksi SMYS) even the AWS classification change can be essential.                                                                                              |
| <b>Direction of welding</b> | Change in vertical welding progression (uphill ↔ downhill).                                                                                                                                                                           |
| <b>Shielding gas / flow</b> | For gas-shielded processes: a change in shielding-gas nominal composition, or a flow-rate change beyond the code's allowance (commonly >±20% of nominal). Verify.                                                                     |
| <b>Electrical / other</b>   | Depending on process: changes in electrical characteristics, filler-metal size range, preheat/interpass and PWHT, and time between passes can be essential. <b>Read the section — the exact set is edition- and process-specific.</b> |

### 3b. Welder qualification — commonly-cited ESSENTIAL variables

|                                 |                                                                                                                                                           |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Welding process / method</b> | Change in process or method of application requires requalification.                                                                                      |
| <b>Direction of welding</b>     | Uphill ↔ downhill progression. (A welder qualified downhill is not thereby qualified uphill, and vice versa.)                                             |
| <b>Filler-metal group</b>       | Change from one filler group to another (commonly grouped 1–4); the code defines which changes are essential.                                             |
| <b>Pipe diameter group</b>      | Change between diameter groups (commonly <2.375 in; 2.375–12.750 in; >12.750 in) — qualification on one group covers a defined range. Verify breakpoints. |
| <b>Wall thickness group</b>     | Change between wall-thickness groups changes what the welder is qualified to weld.                                                                        |
| <b>Position</b>                 | Change in position, e.g. roll ↔ fixed; qualifying in a harder position covers easier ones per the code's range rules.                                     |
| <b>Joint design</b>             | Removal of a backing (or a defined change in joint design) can be essential.                                                                              |

**Exam reflex:** Part C likes “is X an essential variable?” and “does this welder/procedure still qualify after change Y?” Don't memorize — know **which section holds each list** and read the range rule (diameter/thickness/position group) straight off your book. Nonessential examples often cited: number of passes, line-up clamp type, cleaning/grinding method, and (for the procedure) certain minor changes — but confirm each against your edition's text.

## 4. Mechanical (Destructive) Testing — Procedure & Welder Qualification

Qualification test welds are cut into specimens and destructively tested. The **number** of specimens and **which tests** depend on **pipe OD and wall thickness**; specimens are removed from defined locations spaced around the weld. The framework below is stable across recent editions — but read the specimen-count table (historically Table in Sec. 5 for procedure; Sec. 6 for welder) for the exact counts and locations for your job's diameter/thickness.

| <b>Test</b> | <b>What it proves</b>                         | <b>How it's judged (framework)</b>                                                                                                                                                                                                                 |
|-------------|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tensile     | Weld strength meets/exceeds requirement.      | Tensile strength must be ≥ the specified minimum tensile strength (SMTS) of the pipe material; code also addresses where the break occurs and its soundness. Verify pass basis in your edition.                                                    |
| Nick-break  | Internal soundness of the weld cross-section. | Specimen is notched and fractured so the broken face is exposed; the face must show complete fusion and penetration and only limited porosity/slag/incomplete-fusion per the code's size & count limits. Exposes internal defects a bend may miss. |
| Root bend   | Soundness/ductility at the weld root.         | Root placed in tension; bent around a mandrel. Surface must show no crack or open defect exceeding the code limit (commonly ~1/8 in / 3 mm in any direction, with edge exceptions). Verify limit & jig.                                            |
| Face bend   | Soundness/ductility at the weld face.         | Face in tension; same acceptance basis as root bend. Used per the specimen table for the diameter/thickness range.                                                                                                                                 |
| Side bend   | Soundness through the full wall thickness.    | Full-thickness slice bent with the through-thickness cross-section exposed; used for thicker walls in place of face/root bends per the table. Same crack/open-defect acceptance basis.                                                             |

**Specimen count by size (framework, verify exact table):** smaller pipe (roughly < 2.375 in OD) commonly uses nick-break + bend specimens; mid-range and larger pipe add tensile and increase the specimen count; the largest pipe (> ~12.750 in OD) takes the most specimens, removed at equally-spaced locations around the circumference. Wall thickness governs face/root-bend vs. side-bend selection. **Read the specimen-location table for the exact numbers — these are edition/size specific.**

## 5. Two Acceptance Routes — Workmanship (Sec. 9) vs. Fitness-for-Service (Annex A)

|                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Route 1: Standard / workmanship</b> | The default acceptance criteria (historically <b>Section 9</b> ) for visual and NDE acceptance. Limits are based on discontinuity <b>type, individual size, and cumulative length</b> and are intentionally conservative (“good workmanship”). This is what most exams and most jobs use.                                                                                                                                                                            |
| <b>Route 2: Alternative (Annex A)</b>  | <b>Annex A</b> gives <b>Alternative Acceptance Standards for Girth Welds</b> derived from <b>fracture mechanics / fitness-for-service (engineering critical assessment, ECA)</b> . It can permit <b>larger</b> imperfections than Section 9, but only under stricter conditions and with more inspection.                                                                                                                                                            |
| <b>When Annex A applies</b>            | Only when the <b>project specification invokes it</b> , and typically only for circumferential girth welds between pipes of <b>equal specified wall thickness</b> , with NDT on essentially all welds, defined stress/strain limits, no gross strength undermatch, and certain welds excluded (e.g. station piping, valves/fittings, some repairs). Requires an ECA and (commonly) qualified AUT. <b>Confirm the exact prerequisites in Annex A of your edition.</b> |
| <b>Which to use on the exam</b>        | Unless the scenario explicitly invokes Annex A / ECA, apply the standard <b>Section 9</b> criteria. Annex A is the exception, not the default — and it changes the numbers, so never mix the two routes on one weld.                                                                                                                                                                                                                                                 |

## 6. Discontinuity Reference — Type → How API 1104 Evaluates It → Where to Look

API 1104 judges discontinuities by **type**, then **individual size**, then **cumulative length** in a defined weld length — and treats cracks most severely. The standard acceptance limits live in the **Section 9** family (visual, RT, and AUT/UT subsections). Learn the *category* and where each is judged; read the exact figure off your book. Any numbers below are common, cross-cited framework values — **verify against your edition.**

| <b>Discontinuity (abbr.)</b>                        | <b>How API 1104 evaluates it (framework)</b>                                                                                                                                                     | <b>Where it lives</b>                                    |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Inadequate penetration (IP) / due to high-low (IPD) | Root not filled/penetrated as required, or offset from internal misalignment (high-low). Planar; length-limited within a defined weld length; a common pipeline reject.                          | Sec. 9 (visual & NDE acceptance)                         |
| Incomplete fusion (IF) / at cold lap (IFD)          | Weld metal not fused to base metal or a prior pass (incl. IF due to cold lap). Planar; length-limited; treated seriously.                                                                        | Sec. 9                                                   |
| Internal concavity (IC)                             | Root bead fused both sides but center below the pipe inside surface. Often acceptable within limits if density does not exceed the parent metal — judged by density/length. Verify.              | Sec. 9                                                   |
| Burn-through (BT)                                   | Arc melted through the wall / excess drop-through at the root. Judged by individual size and by number allowed in a defined weld length. Verify size & count.                                    | Sec. 9                                                   |
| Undercut — external (EU) / internal (IU)            | Groove melted into base metal at cap toe (EU) or root (IU), left unfilled. Judged by <b>depth</b> (often the lesser of a fixed depth ~0.8 mm/1/32 in or a % of wall) <b>and length</b> . Verify. | Sec. 9 (visual & NDE; note separate visual vs. RT rules) |
| Porosity — individual / scattered                   | Gas pore; a defect if an individual pore exceeds the code size (commonly the lesser of ~1/8 in/3 mm or 25% of thinner wall) and by distribution/cumulative rules. Verify.                        | Sec. 9                                                   |
| Cluster porosity (CP)                               | Localized group of pores; judged by the group's combined diameter within a defined weld length. Verify limit.                                                                                    | Sec. 9                                                   |
| Hollow-bead / piping porosity (HB)                  | Elongated linear porosity in the root pass; judged by individual and cumulative length within a defined weld length. Verify.                                                                     | Sec. 9                                                   |
| Elongated slag inclusion (ESI)                      | Continuous/broken elongated non-metallic slag lines; judged by <b>width, individual length, and cumulative length</b> (often tied to wall thickness). Verify.                                    | Sec. 9                                                   |
| Isolated slag inclusion (ISI)                       | Individual irregular slag pockets; judged by width and cumulative length (commonly limited relative to wall thickness and % of weld length). Verify.                                             | Sec. 9                                                   |

| Discontinuity (abbr.)         | How API 1104 evaluates it (framework)                                                                                                                                          | Where it lives |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| Cracks                        | <b>Any crack is essentially a reject</b> (most severe class), with only very limited edition-specific exceptions for shallow crater/star cracks if any. Default posture: fail. | Sec. 9         |
| Accumulation of imperfections | A separate rule caps the <b>total accumulated length</b> of imperfections in a defined weld length. A weld can pass every flaw individually yet <b>fail on accumulation</b> .  | Sec. 9         |

## 7. NDE / Radiographic Overview

|                        |                                                                                                                                                                                                                                                                          |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methods                | API 1104 addresses <b>visual, radiographic (RT), ultrasonic (UT / automated AUT), and magnetic-particle</b> examination, each with its own acceptance criteria and personnel/procedure requirements. Know which subsection holds each method's limits.                   |
| How limits are applied | For RT and AUT, each discontinuity is classified by type, measured for individual size, and summed for cumulative length within the defined weld length — then compared to the Section 9 limit for that type. Read footnotes and “whichever is less/greater” qualifiers. |
| AUT / ECA link         | Automated UT is the usual inspection basis when a project runs <b>Annex A (ECA)</b> acceptance, since ECA sizing needs height/length data RT does not readily give. If the scenario invokes Annex A, expect AUT and different (larger-flaw) limits.                      |
| Records                | An NDE report should state the method, operator qualification, calibration, and the acceptance regime applied (Section 9 vs. Annex A). Part B document reviews test exactly this kind of completeness.                                                                   |

## 8. Part B / Open-Book Strategy — Speed Is the Skill

|                                  |                                                                                                                                                                                                                                                       |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tab your book                    | Physically tab: definitions, procedure essential variables, welder essential variables, mechanical-test specimen table, visual acceptance, RT acceptance, UT/AUT acceptance, Annex A, and repair. Under time pressure you jump to a table in seconds. |
| Know the address, not the number | For each discontinuity, know its <b>table and whether it is size-, length-, or accumulation-limited</b> — then read the exact figure off <i>your</i> book on exam day. Memorized numbers go stale between editions.                                   |
| Master the gauges                | The replica portion is measurement: undercut/depth gauge, hi-lo, fillet gauge, calipers. Practice reading each to the code's resolution and converting the reading against the acceptance limit — a correct lookup with a mis-read gauge still fails. |
| Drill scenario lookups           | Rehearse “ESI X long in a Y-long weld — accept/reject?” and “welder qualified on 6 in, can he weld 16 in?” Build the reflex of landing on the governing table before reading any value.                                                               |
| Read the whole clause            | Acceptance rows carry footnotes and “whichever is less” qualifiers; on a close call the footnote decides it. Read the full clause, not just the cell.                                                                                                 |
| Section 9 by default             | Apply standard Section 9 workmanship criteria unless the scenario explicitly invokes Annex A / ECA. Never blend the two routes on one weld.                                                                                                           |
| Use YOUR edition                 | Study and sit with the <b>exact edition AWS/API specifies</b> for your test date. Never carry a number from an older copy or any study sheet into an answer.                                                                                          |

## 9. Quick Glossary

|                         |                                                                                                                                                 |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| WPS / PQR               | Welding Procedure Specification (the qualified written procedure) / Procedure Qualification Record (the test results that qualify it).          |
| Essential variable      | A variable whose change requires requalification (affects soundness/mechanicals).                                                               |
| Nonessential variable   | A variable that may change without requalifying.                                                                                                |
| Nick-break              | Soundness test: specimen notched and fractured so the broken face reveals internal porosity, slag, or incomplete fusion.                        |
| Root / face / side bend | Ductility/soundness tests bending the specimen with the root, face, or through-thickness section in tension to expose cracks or lack of fusion. |
| ESI / ISI               | Elongated / Isolated Slag Inclusion — the two slag categories judged separately.                                                                |
| IP / IPD                | Inadequate Penetration / Inadequate Penetration due to high-low (root misalignment).                                                            |
| IF / IC / BT            | Incomplete Fusion / Internal Concavity / Burn-Through.                                                                                          |

|                      |                                                                                                                                                     |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>EU / IU</b>       | External Undercut (cap) / Internal Undercut (root).                                                                                                 |
| <b>CP / HB</b>       | Cluster Porosity / Hollow-Bead (piping) porosity.                                                                                                   |
| <b>High-low</b>      | Internal misalignment of the two pipe ends at the root; drives IPD and root defects.                                                                |
| <b>Accumulation</b>  | Combined total length of imperfections allowed within a defined weld length.                                                                        |
| <b>Annex A / ECA</b> | Alternative girth-weld acceptance via Engineering Critical Assessment (fracture mechanics / fitness-for-service); invoked only by the project spec. |

**Study aid — not a substitute for the API 1104 code book.** Current edition as of 2026: **API 1104, 22nd Edition (2021)** incl. Errata (2023); AWS/API specifies the exact edition for your exam — always verify acceptance limits, variable classifications, and test requirements against **your current API 1104 edition**. Section numbers cited (e.g. “Section 9,” procedure Sec. 5, welder Sec. 6) are locators from recent editions and may renumber — confirm in your copy. Pending welding-SME review before mass distribution. © VoltExam · voltexam.com