

Tube Shop

Quick start guide

Autodesk Fusion on Windows with released Tube Shop 1.10.9

Illustrated review draft · 26 October 2026

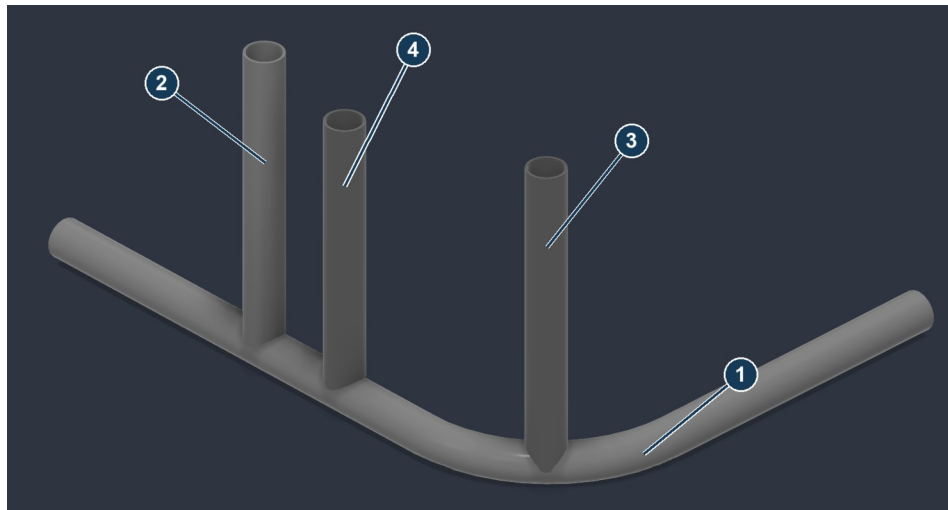


Figure 33. The disposable four-tube example. 1 H1 bent host; 2 I1 imported coped brace; 3 B1 bend follower specimen; 4 B2 straight joint specimen.

Prepare tooling, import or create points, build and edit tubes, cope a joint, then export geometry for downstream tube-laser preparation.

For users who already know basic Fusion selection, navigation, the Browser, and file operations. All dimensions in the exercises are inches unless stated otherwise.

Read page 2 first. Several requested live checks could not be completed. This draft records those limits instead of presenting unverified geometry as a finished result.

Read this before starting

The installed manifest reports **Tube Shop 1.10.9**. The loaded protected modules came from the installed add-in, not this development checkout. Fusion reported **2706.1.14**. Command labels were checked against the installed palette, native controls, and release-tag source.

Observed in Fusion	Not yet established
STEP import; two independent centerline sketches; four new source points; two point-built branches.	Successful reconciliation of the imported solids.
Matching R6 die assignment; fixed-point choices; point update and native Undo.	Nearby host candidate capture, R6 → R4.5 conversion, and resulting branch following.
Ordinary cope; later point update with one cope reapplied; optional tab/slot and shallow-angle specimen.	Physical fit, bend calibration, structural performance, or machine operation.
Eight developed files reopened as solids; one experimental .zx file written.	Opening that .zx in TubePro and validating its receiving-machine setup.

Why the blocked checks matter. Reconciliation, host candidate analysis, and radius conversion encountered “An analytic spine cannot carry both butt closure and a junction-return end relation.” After saving a recovery archive, Fusion was restarted with permission. All three checks reproduced the error in the clean session. The cause still needs diagnosis; this guide does not claim these operations completed.

Image provenance. These are genuine Fusion viewport captures at 1800 × 1125 pixels, with numbered callouts and crops added afterward. Windows full-window capture repeatedly timed out, so native dialogs and the palette are not visible. Dialog screenshots, the successful host-candidate screen, and the converted-radius after view are explicitly missing. No interface mockups or generated geometry images are substituted.

The native commands were opened through the installed palette action handlers and exercised through Fusion’s API. This verifies the recorded command behavior, but is not a complete manual click-through of the interface. The final walkthrough at the end identifies every remaining check.

Protect your work. Use the supplied disposable examples. The build used an isolated demonstration library; the original settings, shop, and die files were verified unchanged. The previously unsaved document was archived before the authorized restart and its recovery copy was reopened afterward.

The example and the delivered files

The input STEP contains H1 and I1. B1 and B2 are added through source points. They share **OD 1.500 in, wall 0.095 in** (38.100 mm and 2.413 mm). The implied inside diameter is 1.310 in. This is an instructional assembly, not a vehicle or structural design.

Tube	Definition / role
H1 Bent host	One 90° bend, CLR 6 in; run intersections (0,0,0) → (24,0,0) → (24,18,0).
I1 Imported coped brace	Originally (10,0,0) → (10,0,12); lower end already coped before STEP export. Its imported end is not square.
B1 Bend follower	(22.242641,1.757359,0) → (22.242641,1.757359,12). Lower point lies at the middle of H1's bend centerline. Host following remains unverified.
B2 Straight joint	(14,0,0) → (14,0,10), later upper Z = 11. Lower end is coped against H1 in stage 9.

Folder / file	Use
models/QS109_Input.step	Start the imported-model exercise with two tubes.
models/QS109_Input_source.f3d	Native source for the STEP, including its initial cope.
models/QS109_Final_demonstration.f3d	Four-tube end state, B2 upper Z = 11; ordinary cope; H1 remains R6. All four new source points were explicitly fixed for isolated tests.
models/QS109_08_Point_update.f3d	Four-tube snapshot with B2 still square; start optional tab exercises here.
models/QS109_Optional_tabs.f3d	Separate perpendicular tab-and-slot specimen.
models/ QS109_Steep_angle_REJECTED_example.f3d	Separate 20° forced-tab diagnostic; do not use as approved joint geometry.
exports/developed/	Actual STEP / IGES blanks, experimental ZX, and export metadata.
screenshots/	Unaltered originals and full-resolution numbered copies.
reference/Demo_die_values.json	Illustrative die values, not a measured calibration or an instruction to overwrite a library.

Open an F3D through Fusion's file-open workflow. Use a separate test profile/library for the exercises. If you recreate the demo dies under new IDs, review and reassign the example's bends; a matching name alone does not restore a saved die reference.

1 Set up the demonstration dies

Purpose: define the stock and tooling before creating or exporting tube geometry.

Palette path: Fusion SOLID → APEX DESIGN → Tube Shop; then the palette's **Dies** tab.

Before you begin: use an isolated test library or separate Windows test profile. Do not replace your normal die library with the supplied reference JSON. There is no separate-library picker demonstrated in this release.

1.1 Select an existing demo die in the Dies list, or choose **+ New die**. Enter a distinctive name, the material, tube OD, wall thickness, and the actual nominal die CLR.

Field	Demo R6	Demo R4.5
Name	DEMO ONLY 1.5 x .095 R6	DEMO ONLY 1.5 x .095 R4.5
Material	DOM (illustrative)	DOM (illustrative)
Tube OD / wall	1.500 / 0.095 in	1.500 / 0.095 in
Nominal CLR	6.000 in	4.500 in
Calibrated CLR	Blank	Blank
Tube K	0.500, illustrative	0.500, illustrative
Measured tests / springback	None	None

1.2 Choose **Save die**. Re-select the saved row and verify every dimension. Repeat for the other demo die. Do not enter the tube outside radius in the CLR field.

1.3 Review the palette header's **CLR** source. "Nominal" uses the tooling label. "Calibrated" uses measured calibration when available; a blank calibrated radius falls back to nominal. The word "calibrated" in a readout is not proof that a physical test exists.

Check: Exactly two uniquely named demonstration dies are available. Both have the same stock size; only the nominal CLR differs. Neither contains measured calibration data.

OD and wall define the tube section. CLR defines the bend's centerline path. Tube K controls the neutral-axis assumption used in length calculations; here 0.5 is an illustrative centerline assumption. Springback concerns the angle commanded on the bender versus the angle the part holds afterward.

Recovery / Cancel / Undo: If units or stock are wrong, correct the die before building. Changing material/OD/wall clears incompatible calibration data. Use **Discard draft** for an unsaved new die. Saved library changes are not a Fusion model Undo transaction; recover a saved change by editing the die or restoring your own library backup.

Evidence gap: The native Dies editor screenshot is unavailable. The values above were saved and read in the isolated library; no fabricated editor image is shown.

1 Calibrate with a physical test bend

The digital example is deliberately uncalibrated. This page is a measurement procedure, not a report of tests performed.

Palette path: Dies → **select the saved die** → Calibration → **Open calibration wizard** →. The separate window is titled **Calibrate a bending die**.

- 1.4 At Cut a test piece**, cut and measure the actual blank. Use the same material, OD, wall, tooling, and bender setup intended for production. Record the cut length. Enable a witness-mark check only if you actually place and measure that mark.
- 1.5 At Bend it**, record **Target bend angle (dial)** and **Angle it holds (after springback)**. Release the load before measuring the held angle. Do not copy the nominal CAD angle into the measured field.
- 1.6 At Measure the bent piece**, choose **Legs to tangent** and measure each straight leg from its cut end to the bend tangent. Alternatively choose **Tip to table** for a held 90° test within 1°: lay one leg flat, measure the highest point of the other cut end, flip the piece, and repeat. Include realistic length uncertainty.
- 1.7 At Rotation check (optional)**, enable the check only if a lengthwise reference line was actually measured. Record its circumferential offset and viewing direction. A measured zero is different from an unchecked test.
- 1.8 At Result**, use **Solve die CLR** when the K assumption is trusted. Use **Solve die K** only when nominal CLR has been independently verified. Inspect the proposed CLR, K, springback, and optional offsets, then Apply the measured result.
- 1.9** Cut and bend a second piece, then check its held angle and dimensions. Confirm the die's test history and springback coverage. Commands outside the measured angle range remain estimates.

Measure on the real setup	Do not infer from CAD
Actual cut length; held angle; tangent legs or both tip heights.	A modeled 90° bend does not measure bender springback.
Witness-mark shift; optional rotation offset; clamp geometry where required.	A die created from an imported bend measures that model, not the tooling.
Repeatability and verification piece.	A successful save does not validate a physical bend.

Recovery / Cancel / Undo: Use Back to correct entries or Close before Apply to leave the stored calibration unchanged. If a result is implausible, recheck units, end A/B, held angle, and tangent definitions. Do not make the numbers fit the nominal die. After a saved result, use the saved history and a known backup when reviewing a correction; Fusion Undo is not the library rollback mechanism.

Evidence gap: No physical test bend or calibration-window screenshot was obtained. Do not use the demonstration values as measured setup data.

2 Import the STEP or start a new design

Purpose: establish correctly scaled, recognizable tube bodies before linking editable points.

Palette path: STEP import uses Fusion's **Data Panel** → **Upload**. Tube tools use **Actions** → **Design** → **Imported tubes** in the Tube Shop palette.

- 2.1 Upload **QS109_Input.step** to a test project and open the translated design. The observed import initially named its bodies Body1 and Body2. Identify the bent member and vertical coped brace, then rename them **H1 Bent host** and **I1 Imported coped brace**.
- 2.2 In the Browser, check Document Settings → Units and use inches for this exercise. Measure OD = 1.500 in and H1 CLR = 6.000 in. H1 lies in XY; the brace rises along +Z. Changing display units alone must not change the physical size.

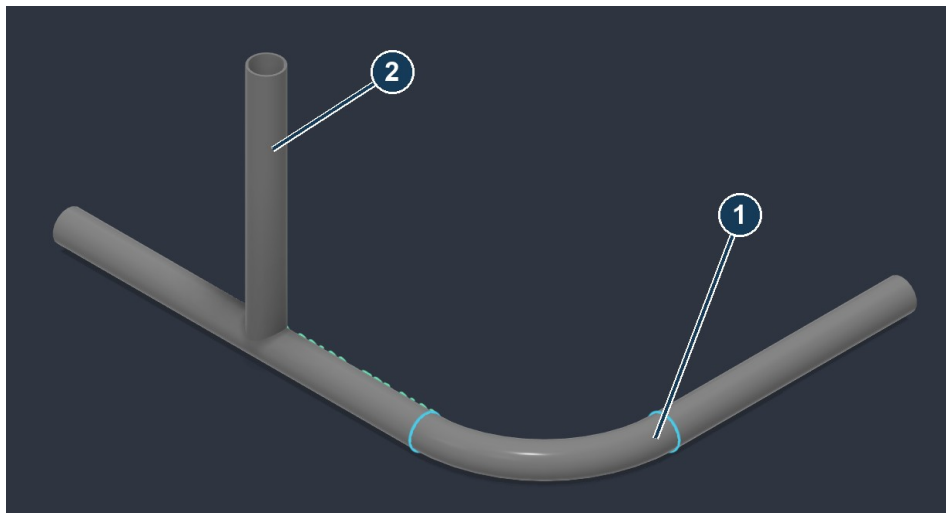


Figure 02. The imported two-body assembly. 1 H1's original R6 bend; 2 I1, already coped at its lower end. Cyan marks are model overlays, not new cuts.

- 2.3 If you need a reconstruction sketch, choose **Extract centerlines** in the distinct **Imported tubes** section. Select H1 and I1, review the selection, and accept. This produced two independent 3D line sketches, five points, and three lines while retaining the solids.

New-design path: create a blank Fusion design in inches. Skip STEP import and reconciliation. In stage 3, place H1's three run-intersection points from page 3; build H1 through them using R6 in stage 4. Then place B1 and B2. Only the new straight branches were demonstrated through this path in the current session.

Check: The imported path has two solids, not meshes, at the stated scale. Extract centerlines is optional: it provides independent unfilleted lines, not live point links on the existing solid. Use Reconcile imported points for that purpose.

Recovery / Cancel / Undo: If scaled by 25.4, stop and inspect the import's units; do not rescale until the cause is clear. Cancel extraction before accepting, or use Fusion Undo after it creates sketches. Remove a mistaken import from the disposable design or reopen the original STEP.

3 Reconcile existing imported solids

Purpose: add source-point identities without rebuilding or duplicating the imported tubes.

Palette path: Actions → Design → Imported tubes → Reconcile imported points.

Before you begin: the imported H1 and I1 solids are visible and recognizable. I1 supplies the already-coped-end case. Keep the original STEP available for comparison.

- 3.1 Select H1 and I1 in the command's tube selector. Inspect the planned endpoints and bend-intersection points. Confirm the target is the existing solid, not an extracted sketch or a second copy.
- 3.2 When the review is valid, choose **Create point links**. The intended result is a linked source-point record with the original body and measured bend radii retained. Do not choose Tube through points to rebuild an already-reconciled tube.

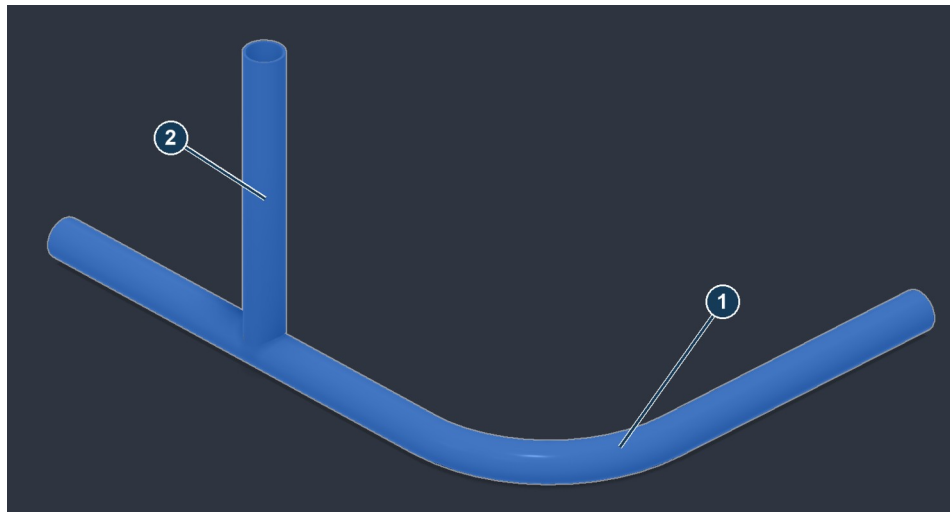


Figure 03. H1 and I1 selected for reconciliation. 1 Bent host; 2 imported coped brace. This is a selection capture, not evidence of successful reconciliation.

Observed stop: this session refused the plan with the analytic-spine error quoted on page 2. No links were applied. Both solids and their volumes remained unchanged after cancellation. The coped-end reconciliation success case therefore remains open.

Supported geometry limit: end cuts must stay wholly within verified straight end regions. Openings, tabs, ambiguous topology, or cuts reaching bends may be refused. The presence of a saddle-shaped end alone does not establish support. Preserve the imported body when a review refuses it.

Check: After a successful future run, select each source point and verify its tube/station identity, run order, and XYZ against the original. Check H1 remains R6 and I1's end profile is unchanged. A point merely near another point must not be assumed to share its identity.

Recovery / Cancel / Undo: Cancel a refused review. This error reproduced after a clean Fusion restart, so preserve the example for diagnosis. Do not erase the cope or substitute a rebuilt solid just to make the check pass. Fusion Undo should remove newly created links after a successful native transaction; that successful rollback was not exercised here.

3 Create the new source points

Purpose: give B1 and B2 explicit, ordered points that can drive later edits.

Palette path: **Actions** → **Design** → **Place points**; native dialog **Place Points**.

3.3 Use the design origin as the reference. Add four rows with the values below. Leave mirror options off. These are independent source points, not selections of the tube's circular rim.

Tube / station	X	Y	Z
B1 / P1 lower	22.242641	1.757359	0
B1 / P2 upper	22.242641	1.757359	12
B2 / P1 lower	14	0	0
B2 / P2 upper	14	0	10

3.4 Inspect the live preview and choose **Keep points**. For a new H1, also place its three intersections from page 3 in run order. Do not add H1's points as a replacement for a refused reconciliation without keeping the imported solid separate.

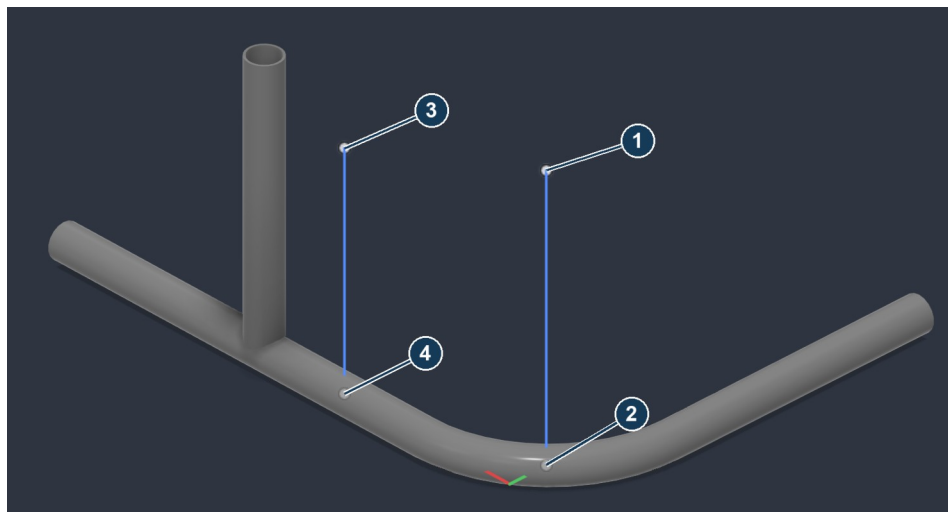


Figure 04. Four-point preview. 1 B1 upper; 2 B1 lower on the bend centerline; 3 B2 upper; 4 B2 lower on the straight host. The visible blue lines are placement previews.

Reference coordinates: without a reference selection, XYZ is relative to the design origin. With a selected reference point, entered values are offsets from that point; each row retains its own reference. Verify the row's Ref value before typing. Picking a different reference does not silently rebase all existing rows.

Check: After Keep points, the Tube points sketch contains the four new points. Inspect position and station identity through the later Tube point coordinates command. Its list numbering can change; identify a point by tube/station and coordinates, not just "Point 2."

Recovery / Cancel / Undo: Cancel discards the uncommitted point placement. Use native Undo after Keep points if the committed set is wrong. If points are at the origin or offset twice, reopen the command and check the reference basis and length units.

4 Build tubes through ordered points

Purpose: create only the new branches and associate compatible stock and tooling.

Palette path: **Actions** → **Design** → **Tube through points**; native dialog **Tube through Points**. Bend choices use **Review bend dies** in Design.

- 4.1 If an imported tube was successfully reconciled, keep that existing solid and its links. Do not run Tube through Points over it. In this session H1/I1 remained imported solids because reconciliation was blocked.
- 4.2 For B1, select its lower source point and then its upper source point in **Points, in run order**. Select **DEMO ONLY 1.5 x .095 R6** under **Bending die**. Check Tube OD = 1.500 and Wall thickness = 0.095 in; leave **Fillet corners at die CLR** on. Leave loop and mirror off. Choose **Build tube** and rename it B1 Bend follower.
- 4.3 Repeat lower-to-upper for B2, using the same settings. Rename it B2 Straight joint. Even a two-point straight branch used the selected die/fillet path here: the earlier “no die” build did not retain the editable source-point record, so it was replaced before continuing.

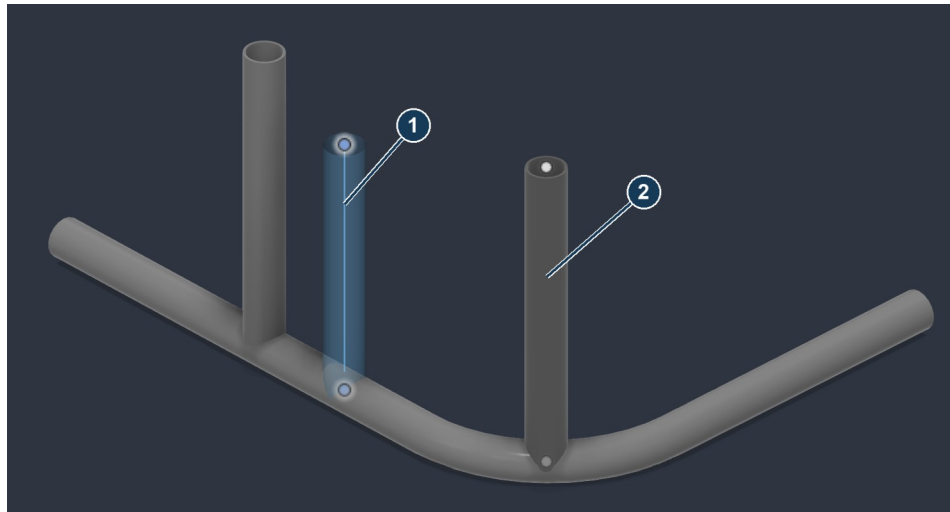


Figure 06. Point-built branches. 1 B2; 2 B1. Each straight branch was built once from its own ordered pair of source points.

- 4.4 Open **Review bend dies**, choose H1's bend and the R6 saved die, then **Stage this bend** → **Apply choices**. This matching assignment succeeded without a radius change. Review individual bends on multi-bend tubes; stage only compatible stock choices. A different-radius choice belongs to stage 6.

Check: Four solids are present. B1 has nominal point span 12 in; B2 initially 10 in. Reopening Tube point coordinates lists both branches' source points. H1's saved bend assignment reads R6 and its geometry remains R6.

Recovery / Cancel / Undo: Cancel the build preview to discard it; use Fusion Undo for a committed build. If a tube doubles back, correct the pick order. If duplicate solids appear, undo the second build. Do not delete or recreate source points casually: their identities drive the existing tubes.

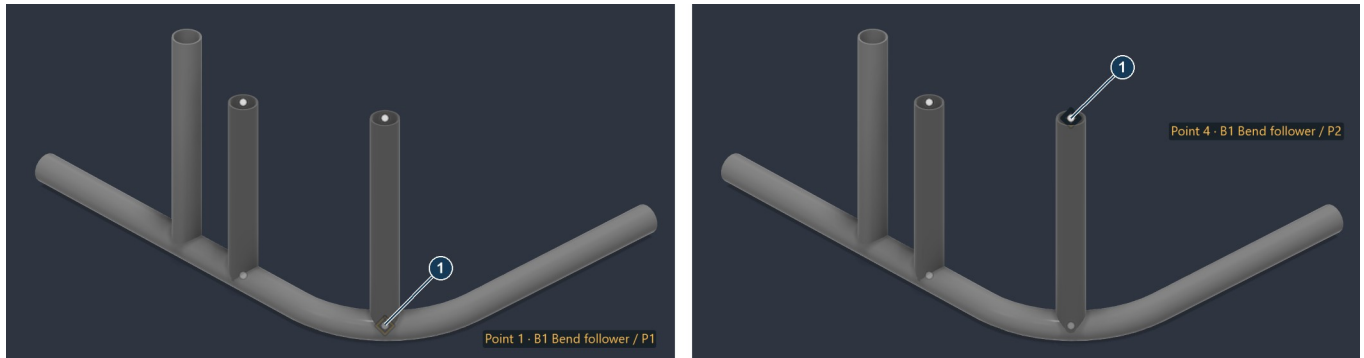
5 Review source point hosts

Purpose: describe what a point should follow before changing the driving tube.

Palette path: **Actions** → **Design** → **Review host points**.

Before you begin: B1/B2 are point-built. H1 is the intended driver for B1/P1. The upper B1 point is to remain fixed. Work with a clean, passing host-candidate review before expecting followers to move.

5.1 Select B1 / P1 in **Source point**. Confirm its lower point is highlighted on H1's bend. Enter **Search radius = 0.125 in** (3.175 mm), then inspect the candidate list and its explanations. The radius is a length in the design's displayed units; start small enough to exclude neighboring tubes.



Figures 07 / 08. Left: 1 highlights B1's lower source point for host review. Right: 1 highlights its upper point for a fixed-space choice. No verified H1 candidate appeared in this session.

5.2 For a valid nearby candidate, choose H1 in **Point follows** and **Stage this choice**. Inspect the proposed reference, station, and any retained offset. A nearby capture can retain an offset; it need not snap the point to the centerline immediately.

5.3 Select B1 / P2, choose **Fixed in space**, and stage it. Review all queued choices before **Apply choices**. Existing links are preserved until explicitly changed. A fixed choice was applied successfully here; host-candidate analysis was blocked.

Demonstration workaround: all four new branch points were explicitly set fixed so the independent coordinate and coping tests could proceed. The delivered final model therefore does not contain a verified B1 → H1 follower relationship. Do not mistake geometric contact for a saved host link.

Check: A successful host assignment changes reference data without moving the geometry immediately. Reopen the review and confirm the driver is H1, not B1 itself or I1. Check the selected point, tube name, and candidate station together.

Recovery / Cancel / Undo: A dependency cycle means a tube ultimately depends on itself—for example, H1 follows B1 while B1 follows H1. Remove the incorrect dependency or keep the independently located point fixed; do not raise the capture radius to bypass it. Remove a queued choice or Cancel before Apply. Applied host choices are intended as one native Undo step.

Evidence gap: The successful candidate list, nearby-capture Apply result, and native dialog image remain unverified. All candidate-analysis errors must be resolved before stage 7 can pass.

6 Convert an individual bend

Purpose: change a bend to available tooling while preserving the intended stock specification.

Palette path: Actions → Design → Review bend dies. Whole-tube changes use the separate **Change tube die** command.

- 6.1** Select H1 under **Tubes (optional)**, or inspect the visible-tube scope. Leave **Include assigned bends** on to review its already assigned R6 bend. Confirm the selected bend, original CLR 6.000 in, OD 1.500, and wall 0.095.
- 6.2** Choose **DEMO ONLY 1.5 x .095 R4.5** under **Saved die**. A conversion choice differs from assigning a die that already matches the model. If eligible, choose **Stage this bend** and inspect **Preview queued geometry** before **Apply choices**.

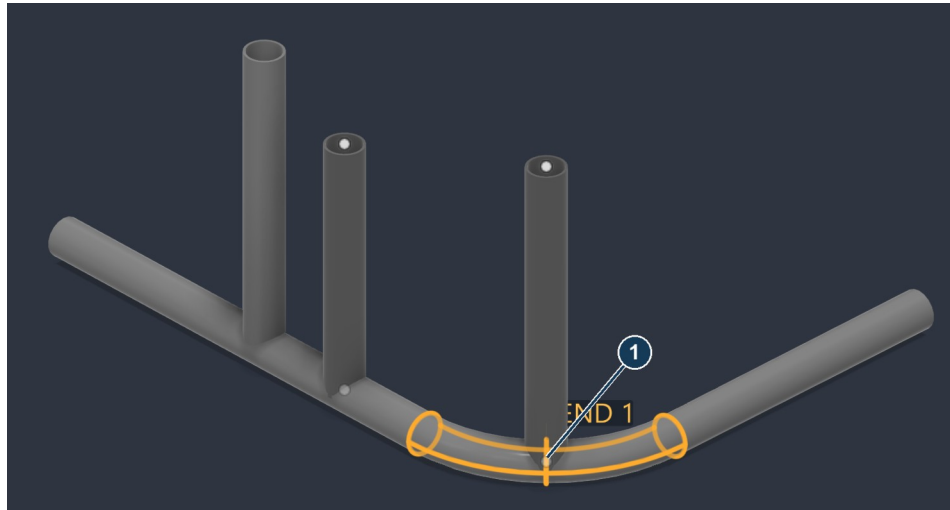


Figure 09. 1 identifies the original R6 bend under review. An R4.5 converted after view was not produced.

Observed result: assigning R6 worked. R4.5 was offered as a conversion but could not be applied because of the analytic-spine error. It was not staged successfully, and the model stayed at R6. This was not a demonstrated “replacement bend cannot fit” result.

Per-bends versus whole tube: this review assigns or converts selected bend stations. Change tube die can change the entire tube’s die and stock dimensions. Do not use the whole-tube command when only one bend radius is intended to change.

Check: After a successful conversion, measure the new centerline radius and inspect both tangent transitions, source points, attached branches, and end cuts. A preview alone is not proof that the committed native geometry passed.

Recovery / Cancel / Undo: If a bend cannot fit, inspect adjacent straight lengths and tangent setbacks. For a simple corner, setback is $R \times \tan(\text{turn angle} / 2)$; adjacent setbacks must fit the available run, with additional real tooling clearance. Choose a feasible die or revise point spacing. Remove the queued conversion or Cancel to keep the original. Use native Undo after a successful Apply; that conversion rollback remains untested here.

7 Verify the branch follows the bend

Purpose: prove the reference relationship by checking coordinates and geometry after a host-radius change.

Palette path: Review host points → Review bend dies → Tube point coordinates. Use **Actions** → **Design** → **Update from points** when a separate point edit has deferred tube updates.

Required before continuing: a verified H1 host assignment for B1/P1, B1/P2 fixed, and a successful per-bend R6 → R4.5 conversion. Those prerequisites were not achieved in this session. This is the remaining acceptance procedure, not a completed demonstration.

- 7.1** Save a before snapshot. Select B1/P1 and record its host, station, XYZ, and any offset. Confirm it is at the half-arc station on H1, not merely near the visible tube surface.
- 7.2** Stage and Apply H1's R4.5 conversion. The native bend review is intended to update queued bends and connected tubes together. Review its result before running any additional command.
- 7.3** If you moved points separately with tube updating off, run **Update from points**. Review affected cope results; use **Update copes** only if a recorded joint still needs recomputing. Do not rebuild B1 with Tube through points as a substitute for following its source points.

Half-bend test coordinate	R6 before	R4.5 calculated target
B1/P1 X	22.242641	22.681981
B1/P1 Y	1.757359	1.318019
B1/P1 Z	0	0
B1/P2	(22.242641, 1.757359, 12)	Unchanged if fixed

The R4.5 numbers are a geometric calculation for a centered half-arc station with zero offset and unchanged H1 intersections. They are **not observed output**. With the upper point fixed, B1 must tilt slightly; a rigid translation of the whole branch would fail this test.

- 7.4** Inspect B1's lower endpoint against the new centerline station and check the actual body meets its driving point. Measure the new H1 CLR, then orbit around the connection. Verify any cope or slot independently; a visually touching solid does not prove the dependency.

Check: Pass only when the saved host reference, new point position, branch endpoint, and committed geometry agree. Capture matched before-and-after views and reopen the saved model to repeat the check.

Recovery / Cancel / Undo: If the point stays behind, inspect its host or Fixed status. If the point moves but the tube does not, check its source IDs and update result. If the branch selects the wrong member or reports a cycle, cancel the pending change and repair the dependency. Undo the conversion to return the assembly to the known before state.

Evidence gap: No successful radius-change after image, verified follower movement, or post-conversion attachment exists in this draft. The delivered final model remains R6 with fixed new points.

8 Move a point and update its tube

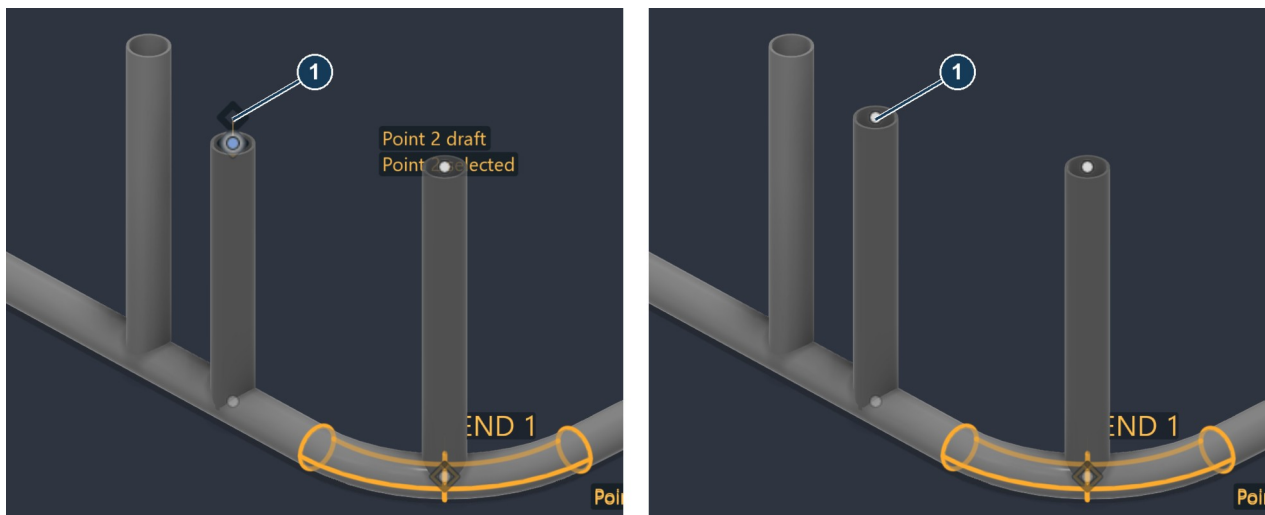
Purpose: make a controlled edit without losing the source-point identity or assigned stock/tooling.

Palette path: **Actions** → **Design** → **Tube point coordinates**; native dialog **Tube point coordinates**.

Before you begin: the four new points are explicitly fixed for this isolated test. B2 is still square-ended at this stage. If a point truly follows a host, change the driver or deliberately detach its reference before editing absolute XYZ.

8.1 Select **B2 Straight joint / P2** under **Source point**, or use **Pick point**. Confirm highlighting is at its upper end. Check the reference readout says a free/fixed source point and shows $X = 14$, $Y = 0$, $Z = 10$ in.

8.2 Enter **Z = 11 in**, leaving X and Y unchanged. Keep **Preview drafts** enabled. Check **Update tubes on Apply** so the point and connected tube are updated in the same operation. These XYZ entries are design-root coordinates; they are not the Place Points offset table.



Figures 11 / 12. Left: the B2 upper point is drafted one inch higher. Right: the committed B2 tube is 11 in between source points. 1 marks the upper station in each view. Other review overlays were still visible in these captures.

8.3 Choose **Apply**. Reopen the command and verify B2/P2 $Z = 11$, the same point ID, and the same source-point order. If Update tubes on Apply was off, run **Update from points** afterward and review its result.

Check: B2 changed from 10 to 11 in. Source IDs were retained: lower tp-a598f1a102, upper tp-8572dcb3ed. Its saved die remained QS-DEMO-R6; OD/wall stayed 1.500/0.095. H1, B1, and the imported coped brace remained unchanged. These IDs identify this supplied example, not future newly created points.

Recovery / Cancel / Undo: Preview is temporary; Cancel discards pending drafts. An unresolved host can reject the whole update: the first attempt did so and left $Z = 10$. Resolve the reference deliberately rather than forcing the update. Native Undo restored 10 in after the successful edit; Redo returned 11 in. A later post-cope retention check is recorded in stage 9.

9 Cope B2 against H1

Purpose: trim the branch end to the host while leaving the ordinary host solid unchanged.

Palette path: **Actions** → **Cope a joint**; native dialog **Cope Joint**.

Before you begin: B2's upper point is at Z = 11. H1 is R6. For the main example, leave **Heel tabs + matching slots** off. B1 is not the target of this cope.

9.1 Set **Joint mode** → **Notched / stationary**. Pick **H1 Bent host** in **Fit against**, then **B2 Straight joint** in **Tubes to cut**. Read both lists before continuing. **Swap the two lists** reverses these roles.

9.2 Review the cutting preview. The branch's lower end intersects the straight part of H1 at X = 14. Keep fit-up gap = 0 for this illustrated geometric exercise; it is not a measured shop clearance.

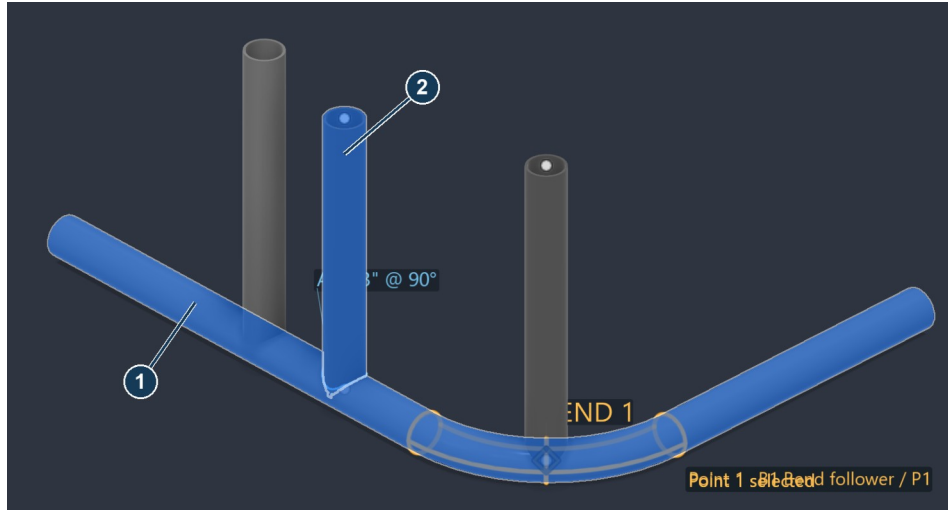


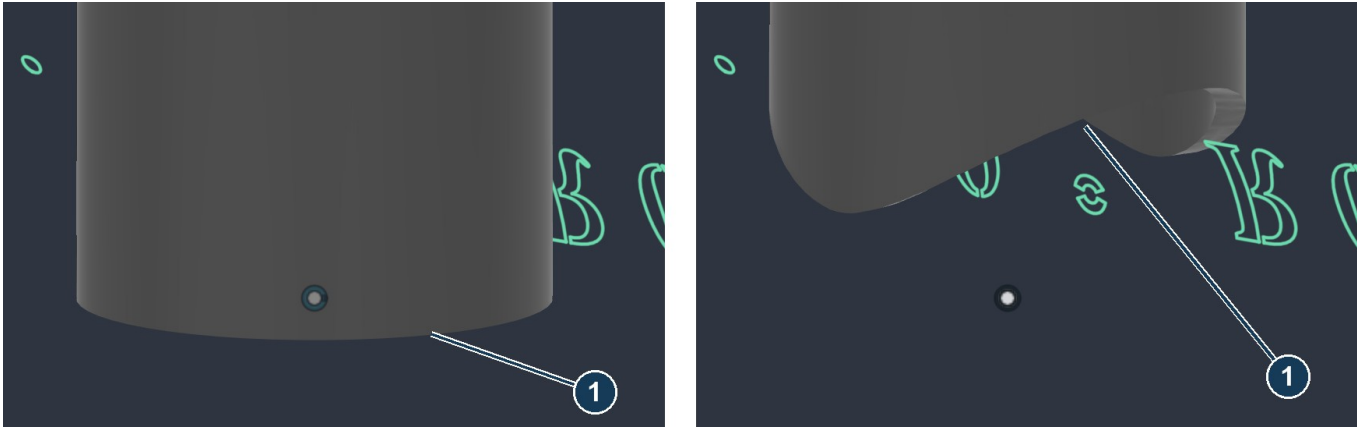
Figure 14. Coping selection. 1 H1 is the Fit against tube; 2 B2 is the tube to cut. Both are highlighted, so the dialog lists—not selection color alone—determine the roles.

9.3 Choose **Cope** and read the result. The command can retain the host for another joint; empty branch selection afterward can mean the previous cope finished, not that it failed. Close the command when done.

Check: The run normalized one cope end. B2 volume changed from 75.586396 to 71.580706 cm³. H1 remained 270.906988 cm³. B2 kept its source record. The imported I1 cope was not altered.

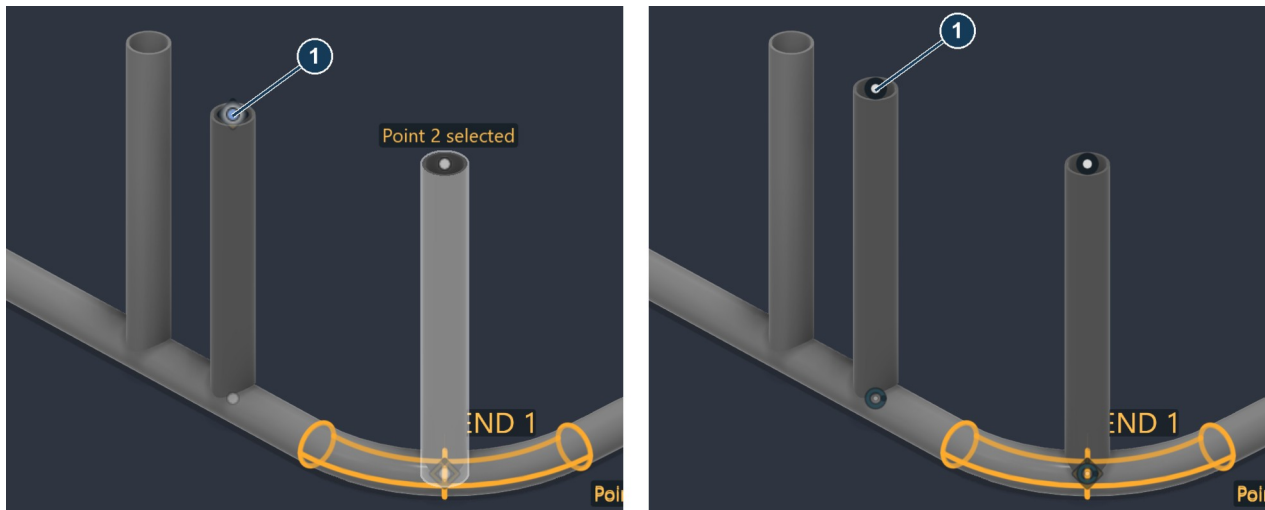
Recovery / Cancel / Undo: If the wrong tube would be cut, Cancel or swap the lists before Cope. After an incorrect result, use native Undo and inspect the restored solid before repeating. Undo restored B2's square end in this test; the intended cope was then reapplied.

9 Inspect the cut and retain it through edits



Figures 17 / 18. B2 end before / after ordinary coping, with the host hidden for inspection. 1 points to the end profile. Hiding the host is a visibility change, not an additional cut.

- 9.4** Hide H1 temporarily and orbit around B2's lower end. Look for a continuous saddle, intact wall, and no unintended island or opening. Restore the host's visibility and inspect the fit from both sides. Do not judge the complete end from a single exterior view.
- 9.5** As a follow-up check after coping, use Tube point coordinates to draft B2/P2 Z from 11 to 12 in with **Update tubes on Apply** on. Inspect the update result and the retained end cut, then Undo this test so the delivered model stays at Z = 11.



Figures 29 / 31. The post-cope verification edit before / after. 1 marks B2's upper station. This later test is separate from the initial 10 → 11 in edit; it was undone before final delivery.

Check: The post-cope edit reported one tube updated and one cope reapplied. B2's end still classified as coped; its point IDs and R6 die remained. Native Undo restored the exact pre-test B2 volume of 71.580706 cm³. The final F3D and exports correspond to this restored Z = 11 state.

Expected manufacturing review: inspect wall condition, cut accessibility, fit-up allowance, and the intended fabrication sequence in the receiving workflow. Digital continuity and a successful transaction are not a physical fit test.

Recovery / Cancel / Undo: If a cut disappears or a saved joint references the wrong body, stop before export. Check the retained source and joint records; try Update copes for a still-valid recorded joint. If repair changes the intended geometry, return to the saved snapshot and redo only that joint.

9 Optional tabs and matching slots

Use the separate square-branch snapshot; keep the main ordinary-cope example intact.

Palette path: Cope a joint → Tab / slot joinery (session only).

9.6 Open **QS109_08_Point_update.f3d** as a separate disposable document. Confirm B2 still has a square lower end and upper Z = 11. Select H1 under Fit against and B2 under Tubes to cut.

9.7 Enable **Heel tabs + matching slots**. Enter **Tab width = 0.375 in**, **Tab reach = Auto: through wall**, **Inside extension = 0.0625 in**, and **Slot tolerance = 0.005 in**. Leave **Min tab angle = 45°** for this 90° joint. Preview, then Cope.

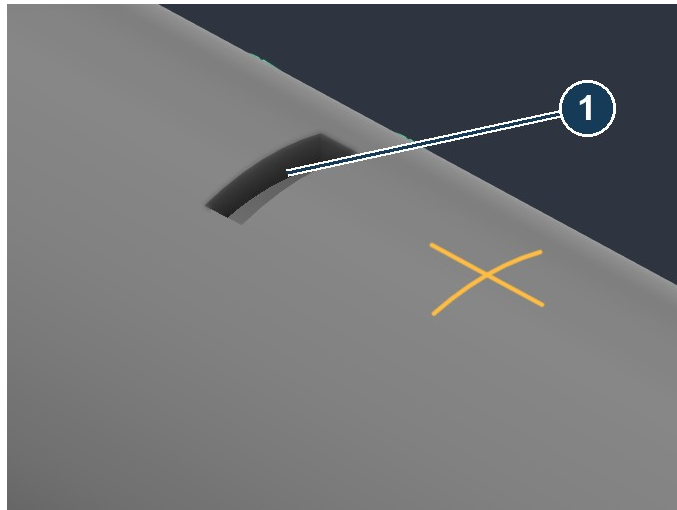


Figure 24. 1 identifies the resulting opening in H1, with B2 hidden. The host is intentionally modified in the tab/slot variant. The gold cross is a marking overlay.

9.8 Inspect the tab and host opening separately, then together. Confirm the tab reaches through the actual host wall with the specified inside extension, has room to insert, and does not contact the opposite wall or another part. Inspect the entire opening, including corners and remaining wall.

Check: The square-branch test retained extra branch material and cut a host slot. B2 finished at 71.641542 cm³ versus 71.580706 cm³ for the ordinary cope. H1 finished at 270.824044 cm³. These observations establish generated geometry, not engagement under real manufacturing tolerances.

Slot tolerance is a geometry input, not a measured laser kerf or guarantee of fit. Measure a physical coupon before choosing production clearance. Auto reach uses wall geometry and angle; do not assume the visible tab projection equals 0.0625 in.

Recovery / Cancel / Undo: Cancel before Cope or Undo the operation. Start from the square blank if you need to preserve tab material: a previously removed cope cannot reliably grow that material back simply by enabling tabs. Close the optional document without replacing the main model. The session's ordinary tab defaults were restored after testing.

Evidence gap: The tab's full underside engagement profile and the native settings dialog still need clearer screenshots. Inspect QS109_Optional_tabs.f3d in 3D before treating that specimen as a fabrication candidate.

9 Reject an oversized shallow angle joint

The 20° specimen is a diagnostic example of what to inspect—not an approved tab design.

9.9 In a separate copy of the square-branch snapshot, move B2/P2 to **X = 4, Y = 0, Z = 3.639702 in**, using Tube point coordinates with tube updating on. The lower station stays (14,0,0), giving 20° between the tube axes.

9.10 For this diagnostic only, enable the same tabs and set **Min tab angle = 0°** to expose the geometry the normal 45° guard would omit. Cope B2 against H1. Do not carry this override into normal work.

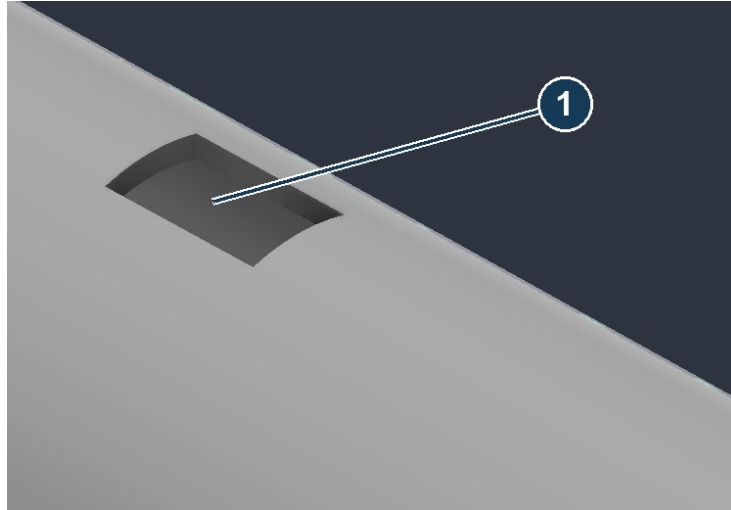


Figure 27. 1 points to the shallow-angle specimen's host opening. The branch is hidden and the camera is centered near X = 10.08 in, where this opening lands.

The run reported a **0.418 × 0.669 in slot**, a **0.375 × 0.7278 in tab**, and an end cope depth of about **4.15 in**. It also warned: **cope angle 20° < 30° (weld access marginal)**. Compared with the short engagement expected at a perpendicular joint, this long opening and cut deserve a fresh design review.

9.11 Reject this forced-tab example for the exercise. Restore the ordinary angle guard and omit tabs at this joint, or revise the joint angle/location and inspect the new result. Check remaining wall, edge distance, insertion direction, access, and physical fit before accepting any variant.

Check: Recognize an impractical slot by its footprint on the actual host, not by the small nominal tab-width number. There is no universal safe slot-size threshold demonstrated here. No structural strength or compact steep-angle tab implementation is established.

Recovery / Cancel / Undo: Undo the diagnostic cope or close its disposable file. Restore Min tab angle = 45° and disable tabs for the ordinary workflow. The delivered rejected specimen is clearly named and was excluded from the main developed and ZX exports.

10A Export developed geometry

Route A produces geometry for downstream tube-laser preparation.

Palette path: Actions → Export tubes; native dialog **Export Tubes**.

- 10.1** Return to the final ordinary-cope document. Select **H1, I1, B1, and B2** under **Tubes to export**. Exclude optional specimens and hidden duplicates. Review **Bending on**; assign unresolved bends before continuing.
- 10.2** Under CAD files, set **Geometry → Developed (straight blank)** and **File format → STEP + IGES**. The other available format choices are STEP (.step) and IGES (.igs). Leave **Assembly file (all in one)** off: that option is an as-modeled assembly, not one developed blank.
- 10.3** For this geometry-only exercise, turn off **CAM G-code**, Bend sheets + die spec, Stock cut list, Wrap templates, and Fabrication packet. Clear Open in Fusion selections if you will inspect the files afterward.

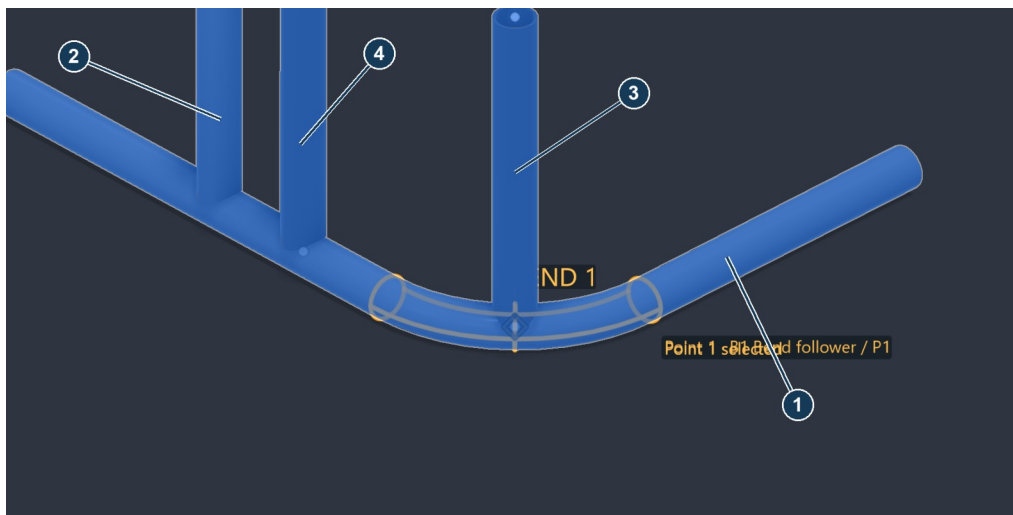


Figure 20. Four selected export tubes: 1 H1; 2 I1; 3 B1; 4 B2. The I1/B2 top ends lie outside the original viewport. The settings dialog is absent; verify the controls in steps 10.1–10.4 explicitly.

- 10.4** Set **Job folder (all outputs)** to your disposable job directory. The demonstrated destination was E:\dev\tube-shop\output\quick-start-1.10.9\exports\developed. Confirm the selection and accept the dialog.

Check: Fusion reported eight developed files for four selected tubes, written under **blanks/**. It initially paused for H1's unresolved bend assignment; assigning the matching R6 die and reopening export allowed the run to finish.

Recovery / Cancel / Undo: Cancel before accepting to write nothing. If die review pauses the job, complete or discard the pending review deliberately and recheck all export settings. Files written to disk are not removed by Fusion Undo. Re-export to a new revision folder rather than assuming old files changed with a later model edit.

10A Check the files in the receiving workflow

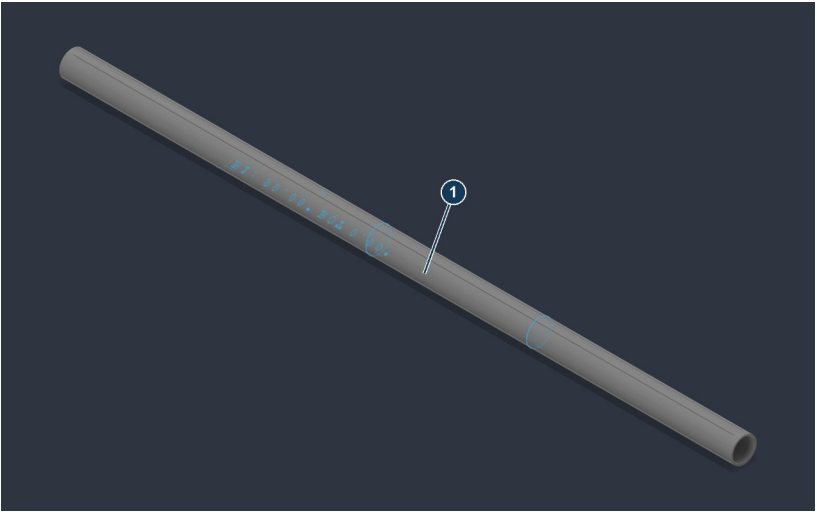


Figure 22. 1 identifies the reopened developed H1 solid. Its R6 bend has become a straight blank; this is exported geometry, not the bent assembly.

Files under exports/developed/blanks/	Observed axial extent
H1 Bent host_developed.step and .igs	39.424778 in
I1 Imported coped brace_developed.step and .igs	11.630712 in
B1 Bend follower_developed.step and .igs	12.000000 in
B2 Straight joint_developed.step and .igs	10.630846 in

- 10.5** Open the required format in your tube-laser preparation software. Each demonstrated STEP and IGES file reopened in Fusion as one solid with **OD 1.500 in**. Check the receiving model physically measures **38.100 mm** if the receiver works in millimeters. The STEP carries an inch conversion unit; do not apply a second inch-to-mm scale.
- 10.6** Inspect both end contours and every mark/opening. The table reports bounding extents of the developed solids, not the original distance between source points or a universal cut-length definition. A cope can shorten that extent. Check your receiver's length datum and how it interprets marking curves.
- 10.7** Configure material/stock, nesting and clamping allowances, cut/mark process mapping, kerf compensation, lead-ins, pierce strategy, tool access, and the correct machine post in the receiving workflow. Simulate and follow the receiving system's setup/verification procedure before cutting.

Check: All eight imports passed basic solid and size checks. H1 and B1 volumes agreed with their source geometry to numerical precision. Coped I1/B2 showed small sampling differences (about 0.03% / 0.06% by IGES volume); contour equivalence and manufacturing tolerance were not certified.

Recovery / Cancel / Undo: If markings disappear, test IGES and inspect free curves/layers; STEP geometric-set curves can be handled differently by receivers. Do not silently convert missing marks into cuts. If scale, contours, or operations disagree, correct the import/setup or export a revised job and recheck it.

10B Export an experimental TubePro nest

Route B exports nest geometry for a supported TubePro installation. It is not a validated cutting program.

Palette path: **Actions** → **Import to CAM**, then enable **Advanced** and open **Nest** → **Output stock** → **TubePro nest (.zx)**.

10.8 From the final ordinary-cope model, open **Import to CAM**. Select the same four bodies under **Tubes to nest** and accept. The native result reported four tubes, one stick, and 13 operations; it explicitly said no files had yet been written.

10.9 Review the Nest display, quantities, rotation/placement, enabled operations, stock, end allowances, and clamp space. Rebuild the nest after changing its inputs. The recorded demonstration used one 96 in stick, a 2 in chuck clamp allowance, and inherited 0.060 in kerf. These were illustrative shop defaults, not a tube-laser machine setup.

10.10 Choose the intended stick(s) in **Output stock** and choose **TubePro nest (.zx)**. This writes one file per selected stock stick to the job folder. Review any bend-die gate before continuing.

Observed output	Value
File	tubepro/QS109_Quick_start_demonstration_stick01.zx
Location	Under the same exports/developed job directory
Size	159,235 bytes
Export manifest	Status complete; no recorded export errors
Warning	Experimental TubePro .zx output: review in TubePro before machining.
Receiver validation	Not opened or simulated in TubePro in this session

10.11 Open a copy in the supported TubePro version. Verify stock dimensions/units, part count and placement, cut-versus-mark intent, operation order, and geometry. Assign and review the actual cutting/marking technology, compensation, pierces, leads, clamping limits, and machine configuration there.

Check: A nonempty ZX file and complete export manifest exist. This establishes file generation only. The recorded nest's plasma/GRBL defaults and time estimate do not validate any laser process or TubePro execution order.

Recovery / Cancel / Undo: If TubePro rejects the file or geometry/order differs, stop and retain the diagnostic file. Use Route A for independent geometry preparation if appropriate. Cancel before export; after writing, file removal or replacement is a separate file operation, not Fusion Undo.

Evidence gap: The Nest controls screenshot and TubePro receiving-software verification are absent. Do not describe this output as machine-ready.

One page workflow checklist

Tube Shop 1.10.9 · Disposable job: _____ · Revision/date: _____

Mark a box only after checking the actual result. This draft's blocked host/reconciliation/conversion checks are not pre-approved.

- ☐ **1 Tooling** — Separate demo library/profile; correct OD/wall/material/CLR. Physical calibration is measured, reviewed, and verified on a second test piece—or explicitly absent.
- ☐ **2 Input** — STEP scale, units, orientation, body names, and solid type verified. Extract centerlines used only when independent sketches are intended.
- ☐ **3 Points** — Existing solids reconciled without shape change, or new points placed with the correct reference basis, identities, run order, and XYZ.
- ☐ **4 Tubes** — No duplicate of a reconciled tube. New source pairs build the intended tube. Stock and individual bend assignments reviewed.
- ☐ **5 Hosts** — Correct host candidates and search-radius units; fixed points explicit; staged choices reviewed; no dependency cycle.
- ☐ **6 Bends** — Original/selected CLR and fit checked. Conversion preview and committed geometry agree; whole-tube changes avoided unless intended.
- ☐ **7 Followers** — Before/after point coordinates and branch attachment checked. Actual update result reviewed; required cope updates complete.
- ☐ **8 Edits** — Controlled point move applied; identities, dimensions, dies, and end cuts retained. Cancel/Undo recovery understood.
- ☐ **9 Coping** — Fit against versus Tubes to cut correct. End inspected from all sides. Optional tabs/slots checked separately; impractical shallow joints rejected.
- ☐ **10 Export** — Final selection and revision match. Route A developed geometry checked in receiver, or experimental ZX checked in supported TubePro. Actual machine setup/simulation complete before cutting.

Final hold points: no unresolved geometry/reference errors; no assumed calibration; no unreviewed receiver units, cut/mark mapping, clamping, or machine setup.

Checked by: _____ Receiver / machine: _____

Troubleshooting reference

Use the smallest reversible correction; keep the last verified model and output revision.

Symptom	What to inspect / recover
Imported body is 25.4× too large/small	Check the original file units and a known OD. Display-unit changes are not physical scaling. Reimport with the correct interpretation.
Reconcile refuses an imported tube	Read the reason. Check straight end regions and unsupported openings/tabs/cuts reaching bends. Keep the original solid; do not rebuild it and call reconciliation successful.
Analytic-spine error quoted in this draft	Cancel and preserve the example and logs. This error reproduced after an authorized clean Fusion restart. The underlying cause needs diagnosis before the blocked operations can be documented as successful.
Points appear in the wrong place	Check inches/mm and the Place Points reference basis. Inspect each row's Ref, not only XYZ. Cancel a bad draft or Undo its committed placement.
Tube does not follow point edits	Confirm the points are the original sources, in order. In this test the no-die straight build lacked point links; the selected demo die with Fillet corners enabled retained them.
No host candidate / wrong nearby host	Check the selected station, visibility, search radius and units. Read candidate errors. Choose the actual driver or an intentional fixed point; do not select a merely nearby body.
Update reports a dependency cycle	Trace the chain of drivers. Remove the incorrect reciprocal relationship or make the independent point fixed, then review again.
Conversion cannot fit	Inspect tangent setbacks and adjacent run lengths, then change die or point spacing. Check real clamp/tooling clearance separately.
Preview moves a point but body stays put	Use Update tubes on Apply or run Update from points. Review failures; a visible draft is not a committed update.
Cope removes the wrong tube / end	Verify Fit against and Tubes to cut. Cancel before applying or Undo the wrong operation. Inspect the original solid before retrying.
Tab absent or slot too long	Start with sufficient square-blank material. Check angle guard, reach mode, clearance, and actual opening. Omit tabs or revise a shallow joint; do not infer strength from generated geometry.
Export pauses / files look stale	Resolve bend-die review, confirm selected final bodies, and write a new revision folder. Old output does not change when the model changes.
Receiver loses marks / rejects ZX	Check units and curve/layer support. Try the appropriate Route A format if suitable. ZX is experimental; do not proceed from file existence alone.

Final walkthrough and evidence record

The saved examples and outputs were checked against the instructions below. “Pass” refers only to the stated digital observation; it does not imply a complete production workflow.

Stage	Walkthrough result
1 · Dies	PASS for isolated demo values and opening calibration review. NO physical measurements; die-editor/window images missing.
2 · STEP / extraction	PASS: two imported solids at the example scale; independent extraction created two sketches, five points, three lines. Original solids retained.
3 · Reconcile / new points	BLOCKED for reconciliation by analytic-spine error; cancellation preserved solids. PASS for four new points and recorded coordinates.
4 · Build / assign	PASS: two straight branches built with source records; matching R6 assigned to H1 without conversion.
5 · Hosts	PASS for staged fixed-space choices. BLOCKED for verified nearby host candidates and H1 attachment.
6 · Conversion	BLOCKED: R4.5 conversion was not applied. R6 geometry retained; no after image.
7 · Following	NOT DEMONSTRATED: no verified host-radius change or following branch. Stage 7 contains the remaining acceptance test.
8 · Point edit	PASS: B2 upper Z 10 → 11, source/die retained; Undo and Redo checked. Initial rejected update rolled back.
9 · Cope / variants	PASS: ordinary cope with unchanged host; Undo; later point update re-applied one cope, then Undo restored final. Separate tab and rejected 20° files saved.
10A · Geometry	PASS: eight files generated; all reopened as one solid each, OD 1.5 in. Sampling differences recorded. Receiver-specific process checks remain.
10B · ZX	PASS for one 159,235-byte file and complete export manifest. TubePro import, operation order, and machine setup NOT VALIDATED.
Session restoration	PASS: original settings.json, shop.json, dies.json hashes unchanged after both sessions. The original document was archived, Fusion restarted with permission, and the recovery copy reopened.

Remaining release-ready guide work: diagnose the error reproduced after the clean restart, repeat the blocked stages after resolution, capture native palette/dialog views, obtain paired successful R6/R4.5 and follower images, show the tab underside clearly, and verify ZX in its intended TubePro installation. Replace this draft status only after those checks pass.

Digital evidence was recorded on 26 October 2026. The API action log and detailed measurements remain in the authoring workspace; the delivery package contains the compact verification record and screenshot manifest.

Screenshot register and source notes

Figures	What the image establishes
02–04	Imported two-body assembly; refused reconciliation selection; actual four-point placement preview.
06–09	New branches; source-point selections; original R6 bend review. Host assignment and conversion success are not shown.
11–12	Controlled B2 point draft and committed 11 in branch. Persistent review overlays remain visible.
14, 17–18	Host/branch cope selection and genuine square-versus-coped end views.
20, 22	Export body selection and actual reopened developed H1. Export dialog is missing.
24, 27–28	Perpendicular host slot; forced shallow-angle opening and joint. Full tab engagement still needs a better underside view.
29, 31	Later post-cope point-update check, subsequently undone.
32	Optional centerline-extraction capture; not proof of reconciliation.
33	Final ordinary-cope assembly, all four bodies; H1 remains R6.

The original filenames retain capture numbering; omitted numbers were redundant or unsuitable intermediate captures. The screenshot manifest records each original hash, crop rectangle, and callout location. Full-resolution numbered copies retain the uncropped original frame. Callouts identify geometry only and do not recreate dialog controls.

Primary source notes

Installed Tube Shop 1.10.9 manifest, palette resources, loaded module paths, native command inputs, and observed Fusion results are the controlling evidence. Release-tag source reviewed: v1.10.9, commit 7b069981b9c7538846f8cc59b4edd136f58245b4. Source code review supports the instructions for blocked steps; it does not substitute for their missing live results.

Autodesk's STEP import guidance supports the Data Panel upload route:

<https://www.autodesk.com/products/fusion-360/blog/import-step-file-into-fusion-360/>

The repository tag can be reviewed at:

<https://github.com/kellyjmcd/tube-shop/tree/v1.10.9>

Scope boundary: no physical machine ran, no production process parameters were validated, and no structural or calibration claims are made for the example. Optional tab specimens were not included in the final ordinary-job exports.