NATIONAL GLASS ASSOCIATION with GANA

Glass Technical Paper **IN03-12 (2023)**

Key Elements of Fenestration System Shop Drawings

Shop drawings for window and wall systems should document and detail all requirements of design parameters, material ordering, fabrication and erection of the glazing subcontractor's scope of work. Failure to properly document and identify these requirements can result in numerous errors and project delays.

Shop drawings are interpretations made by the glazing contractor or material suppliers of the architectural contract documents, including drawings and specifications. Shop drawings should clearly and accurately represent the product being installed and allow the glazing contractor to properly order materials to fabricate and eventually install the glazing system. Shop drawings should be reviewed and approved by architects for compliance with the contract documents.

Shop drawings are developed by the glazing subcontractor primarily to show how, in conformance to the contract documents, it plans to fabricate and install the work. In addition to that, shop drawings play a bigger role throughout a project's life. It is important to convey the information to the architect, but there are several roles the shop drawings fill. For example:

1. Internal to the glazing subcontractor, the shop drawings may be used to prepare quantity surveys or material takeoffs prior to issuing purchase orders for various portions of the work, such as glass, glazing accessories, gaskets, framing system components, finishing, sealants, fasteners, etc.
2. The glazing subcontractor (or the framing supplier) also may use them as the basis for preparing fabrication documents or part drawings of the individual components that have to be cut to length and machined prior to shipping the produced parts to the site for assembly, or prior to any factory-assembled work as may be necessary, such as in unitized walls, or for any post-fabrication finishing that may be required (i.e. formed panels, formed copings, etc.).
3. The general contractor may use them to coordinate not only the work of the glazing subcontractor with the construction of the building structure, but also with any of the other trades associated with the installation of the glazing system. This is critical when it comes to coordination of adjacent trades associated with air and water barriers. Coordination with other trades such as insulation and fire-safing installer (when not included in the glazing subcontractor's scope), a precast panel fabricator/erector into which windows may be set, or a masonry contractor creating rough openings for a strip window system, etc., may also be part of the general contractor's required coordination.
4. Project consultants may also review them for compliance with project specifications, but also to insure, in the case of the project structural engineer, the glazing system is not overloading the structure to which it is anchored.

5. Code officials may also review them to assess compliance with life safety issues, such as safety or fire-rated glazing installations, or proper detailing of perimeter floor fire-safing installation.
6. At project conclusion, the owner and building maintenance personnel may archive a copy for glazing system-related issues, such as ordering replacement parts, or to determine how to make any required repairs.

Technical information in shop drawings typically includes*:

- Framing material type and finish type
- Glass make-up
- Types and sizes of framing members, including elevations with locating dimensions, plan and sections cuts
- Connections to the building structure, or adjacent trades necessary to support the glazing system (i.e. precast panels, stud/sheathing/masonry construction, etc.)
- Methods showing how the glass is glazed into the system and the glazing accessories required to do that (gaskets, setting blocks, edge blocks, etc.)
- Transitions from the glazing systems' perimeter conditions to the adjacent construction
- How the glazing systems will meet specified performance requirements of air, water, structural and building movement (e.g. slab live-load deflection or seismic drift)
- How the glazing system(s) interface with surrounding construction substrates
- Fastener information including type, size, material, finish and spacing
- Door size, rough opening, swing and hardware

* Note the level of detail in the shop drawing will vary based on the complexity of the project. For example some of the information proposed would only be essential if the shop drawings are to include engineering details, which may not be required for more simple building projects.

Details in shop drawings that are often overlooked include:

- **Dimension limits of movements for all moving joints and provisions for expansion and contraction.** Shop drawings should detail and dimension how the system will accommodate building live load deflections, seismic movement, column shortening and thermal movement.
- **Relative layout of walls, beams, columns and slabs with dimensions noted.** Dimension all the tolerances required for installation or that can be accommodated by the system. This is critical for alignment of sealant substrates and anchorage substrates provided by adjacent construction.
- **Perimeter sealant joint sizes, including tolerances and minimum/maximum joint sizes required.** Perimeter joint sizes and tolerances are critical details to ensure proper fabrication and installation.
- **Location of anchorage points for the system and identification of the reaction loads imposed on the structure, including dead load and wind load reactions at each anchor location.** Proper design, fabrication and erection cannot begin without detailed anchorage requirements. This is necessary for preparation of structural calculations. The location of the anchor points can sometimes be moved or adjusted for improved structural performance.

- When a wind tunnel study has been conducted for a project, the resultant positive and negative wind loads are not as simple as using the ASCE 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures typical and corner design wind load.
    - **The shop drawings may use the building elevations** to denote how the wind load is applied to the building as a result of wind tunnel study results.
- **If included in the glazing subcontractor's scope, detailed requirements for insulation materials, fire-safing materials, vapor retarder materials and the installation.** Proper documentation and coordination of these materials with the exterior façade materials is vital to ensure proper design and installation.
- **Designation of the path for water drainage from the system.** Detailing should include the collection, control, containment and evacuation of secondary water infiltration and condensation from the glazing system, the perimeter surrounding conditions and perimeter sealant joints.
- **Installation instructions for the project.** The glazing system manufacturer normally furnishes detailed installation instructions as a separate document. The instructions should include the perimeter framing joint conditions, and not just internal typical joinery conditions. If no installation manual is furnished, it is a common practice to include installation instructions following the cover page of the shop drawings. Any details unique to that particular individual project (i.e., a new corner detail, or perimeter conditions, or a coping that is different than those previously executed, etc.) should be detailed and installation instructions included in the shop drawings.
- **Joinery details.** Shop drawings should provide joinery details showing which framing members run through, and how joints are sealed. Sealant continuity notches should also be included to prevent water infiltration by capillary action across the metal-to-metal joints. Internal seals should be detailed throughout the drawings.

Following is a general checklist of items that should be included, when applicable, in shop drawings for most fenestration systems and is presented in an "Order of Assembly" format for the documents. If not directly included in the shop drawings, other submittals such as structural calculations, product data sheets, manufacturer test reports, etc. may preclude the need to include these items specifically in the shop drawings.

I. GENERAL NOTES

A. **Performance and Design Criteria:** list applicable building codes; design wind, snow and seismic loads; air and water infiltration performance criteria; and live load and lateral displacement movements. Include impact loads and/or blast load performance criteria if applicable to the project.

B. **Aluminum Alloy:** extruded aluminum structural anchors to be (describe alloy). Extruded aluminum anchors will be isolated from direct exposure to concrete. Structural framing members to be (describe alloy). Extruded trim and non-structural extruded shapes to be (describe alloy) .

C. **Finishes:** exterior (aluminum or other material) to be (describe finish). Interior (aluminum or other material) to be (describe finish). Identify paint or manufacturer; color description and designation; pre-application preparation and industry reference standard. This also applies to steel, listed below.

D. **Steel:** structural steel shapes to be A-36 steel with (describe finish). Steel must be isolated to prevent direct contact with aluminum.

E. **Miscellaneous Steel:** stainless to be Series (identify series) with (describe finish) finish.

F. Framing Material other than Metal: framing material to be___ (identify material)___ with___(describe finish)___finish.

G. **Fastener Schedule:** include manufacturer, material, grade, finish, diameter, length, head and point type.

H. **Sealant Schedule:** include manufacturer, product name, product number and color; identify where product is to be used, surface preparation such as cleaning and primer requirements, backer rod type (open or closed cell—must be compatible with sealant type) and material manufacturer, bond-breaker tape material; include industry referenced standards for product.

I. **Glass Schedule:** see below.

J. **Glazing Material Schedule:** if gasket-glazed, include gasket materials, product, manufacturer, color, molded corners, or lineal with field cut corners, open or closed cell material, and reference per ASTM C864 *Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers*, ASTM C509 *Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material* and ASTM C1115 *Standard Specification for Dense Elastomeric Silicone Rubber Gaskets and Accessories.* If other glazing methods are used, such as a tape and silicone cover bead, identify the product, manufacturer and reference standards. If structural sealant or structural glazing tape is used, identify the product, manufacturer; include cleaning, or primer recommendations by sealant or tape manufacturer. Identify manufacturer, material and sizes of setting blocks, and jamb spacers if applicable.

K. **Legend of Symbols:** include any symbols that are used throughout the drawings such as weld symbols, material identification symbols, dead load and wind load symbols, etc.

L. **List of Abbreviations:** provide a list of abbreviations that are used throughout the drawings and provide their full definition. See suggested list below.

II. INDEX OF DRAWINGS

A. Provide a complete list of drawings within the set of drawings. Any revision made subsequent to the original submittal should be identified with appropriate reference marks.

III. GLASS TYPES AND KEY

A. Show location of use by means of text and symbols noted above. Symbols designating glass types can be added to elevations of shop drawings.

B. For description, include manufacturer/fabricator, product designation name and product number.

C. Designate the glass type, and detailed construction with each location including:

- Glass substrates, thickness, strength requirements (annealed, heat-strengthened, or fully tempered).
- Coatings (including surface location), decorative frits and opacifiers where applicable.
    - For sealed insulating glass units, air space width, gas fill (where applicable), spacer material, primary and secondary seal materials.
    - For laminated glass also include the type and thickness of the interlayer material and the overall product thickness.

D. Include reference to type of glazing system being utilized, captured vs. structural silicone glazing, point-supported, etc.

E. Special requirements, such as pattern (non-rectangular) cuts, or radius edges are usually referenced via the elevations, and do not need special callouts in shop drawings.

F. Hole location for point-supported hardware may be added, especially as it relates to ensuring the glass can adequately accommodate the fixtures and the loads imposed on the glass.

IV. GENERAL DRAWING INFORMATION

A. **Die Schedule:** show each shape used with proper die number listed and state alloy and temper requirements. Show finish surfaces and provide "I" value for the shape if it is an aluminum extrusion used as a structural element. Provide die drawing for gaskets, setting blocks or other shapes used in the glazing of the system or in the assembly of the system.

B. **Installation Instruction Drawings:** by having the Installation Instruction Drawings in shop drawings, whether after the cover sheet or at the end of drawings, the installer has this vital information for his use in the field during the installation of the work. It also provides the drafter who is preparing the drawings the ability to intimately understand the system requirements. Any project-specific conditions which alter the standard installation instructions can also be addressed by the drawings being prepared for the project, with changes made in the installation instructions so these conditions are brought to the attention of the installers. Should include sill splices, whether a sill can or flashing.

V. DIMENSIONAL CONTROL

A. The dimensional control is meant to show the in/out, left/right, up/down placement of the glazing system in relation to the building grid and elevations. It is also used by the architect to quickly establish the glazing system is correctly located on the project in relation to column grid lines and datum elevations. Therefore, the dimensional control conveyed in the shop drawings is clearly recognizable as properly correlated to the contract drawings.

B. Dimensional control is meant to correctly locate the glazing system in relation to not only the building structure, but also in relation to other trades adjacent to the placement of those glazing systems.

C. Establish how dimensional control will be conveyed on the shop drawings, including, but not limited to:

- Floor plans, elevations and sections.
- Embed layout and placement drawings.
- Details.

D. With input from installation crews, determine where on the glazing system the dimensional control points will be taken. Options range from:

- Face of glass (on structural silicone glazing systems) and framing centerlines.
- Exterior face of cover caps/framing centerlines (on captured systems).

- Back of mullion/framing centerlines—this might be the best option, as it gives the field crews a hard point to start the installation of the framing, as opposed to face of glass or exterior caps, which are more theoretical points prior to installation.
- On segmented plan layouts, the dimensional control point may be the intersection of the face of glass on two adjacent surfaces and the framing centerlines.

E. On the details, this dimensional control point is often referenced as the "working point," and is designated by a datum mark, or other symbol easily distinguished on details and plans.

F. There should be an easily understandable correlation between control dimensions on elevations, plans and sections with the details. Dimensions on details are called out as "TO COL LINE "X," or "TO DATUM ELEVATION (give elevation in "+X'-XX" format).

VI. EMBEDMENT DRAWINGS FOR ANCHORAGE

A. When the means and methods of anchorage of a wall system include embeds in concrete (pre-cast or poured in place), this section is relevant to the embed design and placement. This section does not apply when other anchorage such as expansion anchors or bolting or welding to steel structure are utilized.

B. **Structural components:**

- Note that specific consideration for general structural components (as provided by others), should be part of the shop drawing layout and preparation process. However, design components which are deemed necessary for the structural performance/integrity of the fenestration product (e.g. kickers, steel reinforcing, embeds, etc.) typically require a formal Structural Engineering review. The engineering notes would then be incorporated into the shop drawings prior to a final submittal.

C. **Embedment drawings:**

1. Provide plan, section and detail views of the embed layout.
2. Scale for these drawings ranges toward the smaller side of common architectural scales, such as 1/16-inch / 1/8-inch / ¼-inch = 1-ft-0-inch.
3. Include Dimensional Control Strategies (i.e. layout reference dimensions from c/l of columns, etc., and/or datum elevations (up/down) to locate the embeds as discussed above.
4. All embeds, regardless of the type, size or quantity, such as steel plates or angles with headed welded, concrete studs, or "Halfen" or "Unistrut" type anchors, steel tubes or other devices that are to be cast into a concrete structure or the poured concrete floor of a steel building, are all shown in layout and section cut details.
5. Part Numbers: use part number references for identifying which particular embed is to be placed at each location. Detail, in plan view and in section view, the location of each embedment. Show the size of each embedment. These views should also show at least two ¼-inch holes to use to attach the embeds to the form.
6. Coordinate the location of glazing system embeds with any other embedment in the concrete structure such as post tension cables or embedments for other trades.

VII. FLOOR PLANS AND PLAN VIEWS OF FRAMING

A. Scale for these drawings ranges toward the smaller side of common architectural scales, such as 1/16-inch / 1/8-inch / ¼-inch = 1-ft-0-inch.

B. Show frame identification reference marks to locate where the frames are to be installed.

C. Include compass (north, east, south, west) orientation references as an assistance to the installer for reference in the field. Or use the naming conventions or descriptions used in the contract documents.

D. Street orientation is also advisable.

VIII. ELEVATION DRAWINGS

A. **Dimensional Control:** develop the strategy as described above for the elevations, to aid the installation crew in locating the glazing system in relation to the building grid and datum elevations. This strategy should be consistently used throughout the drawings. Dimensions shown in elevations should also be clearly seen in plans, sections and details.

B. Scale for these drawings ranges toward the smaller side of common architectural scales, such as 1/16-inch / 1/8-inch / ¼-inch = 1-ft-0-inch.

C. For left/right placement of the glazing system, dimensions may be taken from building control lines to outside of the framing members (frame dimension), to rough opening locations, or to framing member centerlines.

D. Up/down location is also taken from building control points (top of slab datum elevations, finish floor datums, etc.) to rough openings, frame dimension points, or to member centerlines, or to top of framing members (i.e., top of horizontal, to top or bottom of vertical mullions, etc.).

E. Include center-to-center framing references, daylight openings, rough openings and frame dimensions as required.

F. Include work points and reference points. These are coordinated with and derived from the information provided in the architectural drawings.

IX. SECTION DRAWINGS

NOTE: *If possible, these section-drawing views, taken as vertical cuts through the glazing systems (as opposed to plan views), should be drawn on the elevation drawings. This will make it easier to coordinate the required information. For coordination purposes, it may be necessary to draw a composite drawing of floor slab, top of slab, and ceiling horizontal to a smaller scale with relative dimensions to indicate dimensional understanding of the spandrel, or parapet details. The smaller-scale details can be keyed and/or referenced to full-size details for clarity.*

A. Develop the dimensional control strategy as described above for the section views to aid the installation crew in locating the glazing system in relation to the building grid and datum elevations. This strategy should be consistently used throughout the drawings; dimensions shown in elevations should also be clearly seen in plans, elevations and details.

B. A good scale for sections, if not included on elevations but as stand-alone details, is 1/4-inch = 1-ft-0-inch.

C. Detailing should show accurate surrounding conditions, including soffits, parapet caps and floor conditions. For punched windows, show the location of sill referenced to finished floor.

D. Locate the insulation, fire-safing line. Identify the products being used, including the thickness of the insulation, method of attachment and methods of reinforcement at the floor line.

E. Identify the location of anchors to the structure or surrounding condition. Show any variation in the location of the structure in relation to the wall as may be present. Show surrounding conditions to determine if any interference occurs with other work around the opening or the attachment point.

X. DETAILS

A. Details are usually drawn at least at half- or full-scale. They may be enlarged plan, section or elevation views, either cut vertically or horizontally through the framing system details. Due to their enlarged size, they offer more clarity as to the specifics of the glazing system being proposed for the job. They depict all materials required in the assembly/installation. Details should call out any special fabrication and/or erection requirements including notching, sealing and torque of bolts if required.

B. Typical detail section cuts are normally included in these drawings.

C. **PERIMETER CONDITIONS** make up the largest part of the detail section of drawings, as they show how the glazing system interacts with and installs to surrounding conditions, typically furnished and installed by other trades.

1. Any special installation requirements not covered in the manufacturer's installation instruction drawings need to be addressed, also, not just typical system joints. Perimeter condition drawings must show these perimeter conditions.

2. Joint sizes between the glazing system and surrounding conditions shall take into account all movement of structure (live load, column shortening, etc.); seismic and thermal expansion/contraction of the glazing system are shown, and should be clearly identified as to the factors that were used to determine the joint size.

3. Other substrates' installation tolerances, such as rough opening tolerances, should be shown, as they also impact the joint size and/or the size of the rough opening and the size of the glazing system being installed in the opening.

4. Air/water/thermal barrier lines should be clearly traceable from the glazing system to the appropriate materials in the surrounding conditions without interruption.

5. Secondary Water Control: determine method used to accommodate secondary water from adjacent perimeter materials into the glazing systems. Detail how secondary water is controlled, collected and removed to the exterior of the wall system. Utilize baffles behind drain holes to provide an insect barrier and to limit excessive air infiltration. Detail how condensation in the wall system will be collected, contained and controlled.

D. **Joinery Details:** shop drawings should provide joinery details showing which framing members run through and how joints are sealed. Sealant continuity notches should also be included to prevent water infiltration by capillary action in the metal-to-metal joint and internal seals should be detailed throughout the drawings. This is also in direct reference to the second paragraph of this document.

E. **Reinforcing Details:** the details should call out all reinforcing material sizes, length and location in the hosting member. The details should also indicate how the reinforcing is retained and/or located within the system, and callout of any materials (fasteners, welds, etc.) per structural calculations, as well as how dissimilar material separation (when required) is maintained.

F. **Ordering Information:** adequate information to order all materials. Examples include, but are not limited to:

    1. Glass: In addition to the information conveyed in III Glass Types and Key (above), the details show glass bite, lap dimensions at expansion joints, etc.

    2. Fasteners: material, head type, length, diameters, thread type, spacing and finish.

    3. Gaskets: material, durometer and corner construction,

    4. Glazing accessories, such as setting blocks (durometer, size, length, where located in relation to glass width) and edge blocking (when required).

    5. Extrusion/component finishing, including that for brake metal, the main frame components or other materials.

G. **Verification of Condition:** areas not clearly defined in the contract documents should be clouded to draw attention to these areas so the architect and/or general contractor can provide verification of the design intent and verification of conditions.

H. **Materials by Others:** materials not provided by the manufacturer and/or glazing subcontractor should be noted as "BY OTHERS." However, the materials should be drawn and identified as to who will be furnishing and installing the materials. This is important so the architect and the contractor can assign the work to the appropriate trade, who in turn will be responsible for supplying and installing the materials in question.

I. **Contract Deviations:** deviations from the contract documents should be clouded and identified as deviations so the architect/contractor are made fully aware of the changes being made and have the opportunity to make any comments necessary during the review process.

J. **Material Expansion internal to the system, to surrounding conditions:** detail how expansion of materials is accommodated, including anti-friction washers, bolt locations in slotted holes, use of lock nuts instead of lock washers, location of round holes for pinning of materials. Show method used for sealing of expansion joints. Detail joints so three-way adhesion of sealant does not occur. Provide properly shaped materials at expansion joints and perimeter conditions so sealant joint can accommodate the use of proper backer rods for sealant joints. Include male/female mullions for in-plane lateral thermal movement of the wall system.

K. **Thermal Insulation:** detail the thermal insulation in the wall and the location of any vapor retarder, indicating how the perimeter of the retarder is closed off so the integrity of the retarder is assured. Address any penetrations of the retarder such as at anchor locations. Detail the fire-safing and the smoke seal.

L. **Anchorage to the Structure:** fully detail all anchorage of the wall to the structure, showing separate details for wind load and dead load anchors. Clearly identify all parts of the anchorage including materials such as shims, anti-friction slip washers, bolts, nuts and flat washers. Dimension in/out, left/right and up/down tolerances for erection and for installation of embeds.

M. **Interior Finishes:** coordinate any glazing system conditions which interface with surrounding conditions such as blind pockets for interior mini blinds or shades, register grilles for mechanical units, louvers for mechanical systems, exterior sunshades, interior light reflectors, blast curtains or other special conditions which are part of the project.

N. **Special Conditions:** detail any special parts of the wall system, such as window washing tie-ins or building maintenance unit tracks/guides.

O. **Seismic & Blast Requirements:** identify any special details required for seismic movements, for blast resistance or for impact loads.

P. **Structural Calculations:** coordinate all details with the structural calculations prepared to substantiate the design shown on the drawings.

Abbreviations and Symbols

NOTE: This suggested list is not intended to be comprehensive. Check with the manufacturer or glazing subcontractor for any additions or deviations.

Shop Drawing Abbreviations

ARCH	Architect	MO	Masonry Opening
BO	By Others	NIC	Not in Contract
AR	Arch Reference	NTS	Not to Scale
CL	Center Line	OC	On Center
DIM	Dimension	OD	Opening/Overall Dimension
DL	Dead Load (anchor)	OPP	Opposite Hand
DLO	Daylight Opening	REF or RD	Reference Dimension
DO	Door Opening	RL	Rafter Length
DS	Door Size	RO	Rough Opening
ELEV	Elevation	SL	Stock Length
FD	Frame Dimension	SIM	Similar
FF	Finish Floor	TBD	To be Determined
FH	Frame Height	TOH	Top of Horizontal
FO	Face of… (Slab, System, Exterior Cap, Glass, etc.)	TOS	Top of Slab
FS	Frame Size	TOSTL	Top of Steel
FW	Frame Width	UNO	Unless Noted Otherwise
GB	Glass Bite	VIF	Verify in Field
GC	General Contractor	WD	Window Dimension
IS	Infill Size	WL	Wind Load (anchor)
MH	Mullion Height	WP	Work Point
ML	Mullion Length		

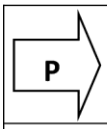
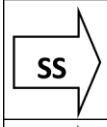
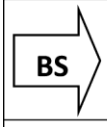
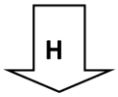
Fastener Abbreviations

A PT	A Point	HWH	Hex Washer Head
AB PT	AB Point	LWIT	Lock Washer Internal
B PT	B Point	MS	Tooth Machine Screw
CAD	Cadmium Electroplating	OH	(full thread) Oval Head
CS	Cap Screw (partial thread)	P	Phillips
FH	Flat Head	PH	Pan Head
FHUC	Flat Head Undercut	RH	Round Head
FPT	F Point	SDST	Self-drilling/Self-tapping
FW	Flat Washer	SKTH	Socket Head
GR 2	Grade 2	SQH	Square Head
GR 5	Grade 5	SS	Stainless Steel (304 cold worked)
S	Slotted	ST	Self-tapping
HH	Hex Head	TRH	Truss Head
HJN	Hex Jamb Nut	ZINC	Zinc Electroplating
HN	Hex Nut		

Example of Fastener Description

Size x Length	Head	Type / Point	Material / Plating
10 x ¾-inch	Phillips, Pan Head	A Point	Stainless Steel

Symbols in Shop Drawings, example list

	Perimeter Seal		Erector Seal
	Shop Seal		Splice
	Brake Splice		Horizontal Splice
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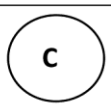
	Field Attach		Shop Attach
	Shop Cut to Size		

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This Paper was developed by dedicated member volunteers and subject matter experts. The original version of this document was approved and published in 2012. This version of the document was updated and published in January 2023.