3. CAN CONSTRUCTION AND INTEGRITY FACTORS

There are a wide variety of potential can defects. This is due to the many steps involved in producing a filled can. In order to assess can integrity, information regarding these various steps is required.

3.1 Metal Plate

Ingots of steel or aluminum of predetermined chemical composition are sent to their respective rolling mills. Here the ingots are rolled into very long, narrow, thin (0.010 in.), continuous sheets; these strip sheets are rolled into coils. The coils of steel are passed through a tin bath or a chromium bath in which either of these metals are electroplated onto steel to produce electrolytic tin plate (ETP) or tin free steel (TFS). The tin layer is approximately 15 millionths of an inch thick while the chromium layer is 0.8 millionths of an inch thick. The coils of aluminum may or may not receive a surface treatment. The respective metals are shipped to the can making plants in coil form.

Once these coils arrive at the can making plant they are cut into sheets. These sheets vary in size according to the size of can to be made but are approximately 1 meter by 1 meter.

3.2 Organic Coatings

There are many types of organic coatings: phenolic, oleoresinous, acrylic, epoxy phenolic, polybutadiene, to name a few. The type to be applied will depend on the product to be canned, the expected shelf life and, in the case of outside coatings, appearance requirements. Organic coatings tend to serve as a barrier between the metal and the can contents or environment.

The coatings are applied to each sheet by means of rollers. The sheets then pass through a bake oven where the coatings are cured. Depending on requirements, the inside may be single or double coated and the outside given a plain coat or a lithographed label. Inside coatings are applied first; each coating is baked prior to application of the next. Aluminum and TFS are always inside coated; TFS is always outside coated. ETP may or may not be inside or outside coated depending on requirements.

When coating sheets are destined to become the bodies of three piece cans (soldered or welded), a plain (uncoated) narrow strip or margin is left along the two sides that will form the side seam. Can bodies cannot be soldered or welded without these margins. Margins are usually not left on sheets from which ends or two piece cans are to be made.

3.3 Can Body Manufacture

3.3.1 Three Piece Cans - Soldered

These can bodies are made only from ETP. The plain or previously coated sheets are fed into a slitter which cuts the sheets into individual can body blanks. These blanks are then fed into a body maker where they are slit, notched, the side seams are hooked, interlocked, tightened, fluxed and soldered after which inside and outside side seam stripes (organic coatings) are sprayed along the side seam if required.

Depending on requirements, the can body may be beaded. Beads are formed in: a) the bodymaker during cylinder formation; or b) in a beader flanger after side seaming. The soldered cylinder is flanged after which an end is applied. The open top can is then air pressure tested and palletized for shipment to the cannery.

3.3.2 Three Piece Cans - Welded

Sheets of steel (ETP or TFS) previously organic coated as required are similarly slit into individual can body blanks. These body blanks are slightly longer than the perimeter of the welded cylinder. The body blanks are fed into the body maker where the cylinder is formed. The edges forming the side seam overlap slightly. These edges are bonded together using electric resistance or laser welding. Once the cylinder is formed an inside and outside side seam stripe is sprayed on as required. The cylinder is then flanged, and an end is applied. The open top can is air pressure tested in the usual manner.

Welded can bodies may also be beaded. This operation is done after the cylinder has been welded and side seam striped but before the end is applied. Beader flangers and Krupp can-o-mat are two common beading machines.

3.3.3 Two Piece Cans

Sheets of steel (ETP or TFS) or aluminum, previously organic coated as required, are cut into strips which are fed into a press. A disc is cut out and then in one (single draw) or more (draw-redraw) operations the metal is stretched and worked to the desired flanged height and bottom profile. This basic can advances to the trim press where the extra flange metal is cut off. If the can body is to be beaded, the can advances to a separate station (beader) where the bead is formed. This finished container is then air pressure tested and packaged for storage and/or shipment to the cannery.

3.4 Can Ends Manufacture

3.4.1 Round Ends

Coated or uncoated sheets are cut into strips and fed into a single or double die press. In one operation the disc is cut out and the end profile (contour) is impressed in the metal. The disc then drops into a curling wheel which bends the cut edge to form the curl. This round basic end progresses to the compound line where, under a stationary nozzle, the end is rotated. During rotation the nozzle dispenses compound into the curl area.

3.4.2 Non-round Ends

These ends are cut into strips in a manner similar to round ends. They are usually held stationary while curling rolls follow the end perimeter to form the curl. At the compound liner station the end is again held stationary while the nozzle travels the seaming panel perimeter and dispenses compound.

3.4.3 Pull-Tab Can Ends

These are made from flat profile (non-beaded or basic) ends. The basic ends are fed into a conversion press in which the end is scored, the flat profile modified with strengthening and convenience features and the rivet is formed. Tab stock (coil of metal approximately 3 cm wide) is fed into the press where the pull tab is formed. The pull tab then advances to the modified basic end to which it is attached at the rivet.

It is easiest to make these type of ends from aluminum. Many types are also made with ETP and a few are made with TFS. Steel (ETP and TFS) easy open ends may be fitted with aluminum pull tabs.

3.4.4 Key-open Can Ends

These ends are made in a manner similar to those described above. The key tab is an integral part of the end curl which is die formed. The key is usually spot welded to the end panel.

3.5 Double Seam Formation and Integrity Factors

Ends are applied to the vast majority of food cans by machines called double seamers. The double seamer takes its name from the fact that the double seam is formed in two distinct operations. In the majority of double seamers these two operations are performed by seaming rolls. The can body and end are clamped on a seaming chuck by a load applied vertically to the base plate or lifter (see Figure 3.5.a). The first operation roll, tucks the end curl under the can flange such that they become interlocked (Fig. 3.5.b). The second operation roll compresses these interlocked layers of metal, squeezing the compound into the voids to complete an hermetic seal (Fig. 3.5.c). In canneries the double seamers are more appropriately called closing machines. These are variously equipped to apply an end to a filled can under a number of specific conditions dependent on the product and the packer's needs such as vacuum closure, steam flow closure and vacuum gas closure.

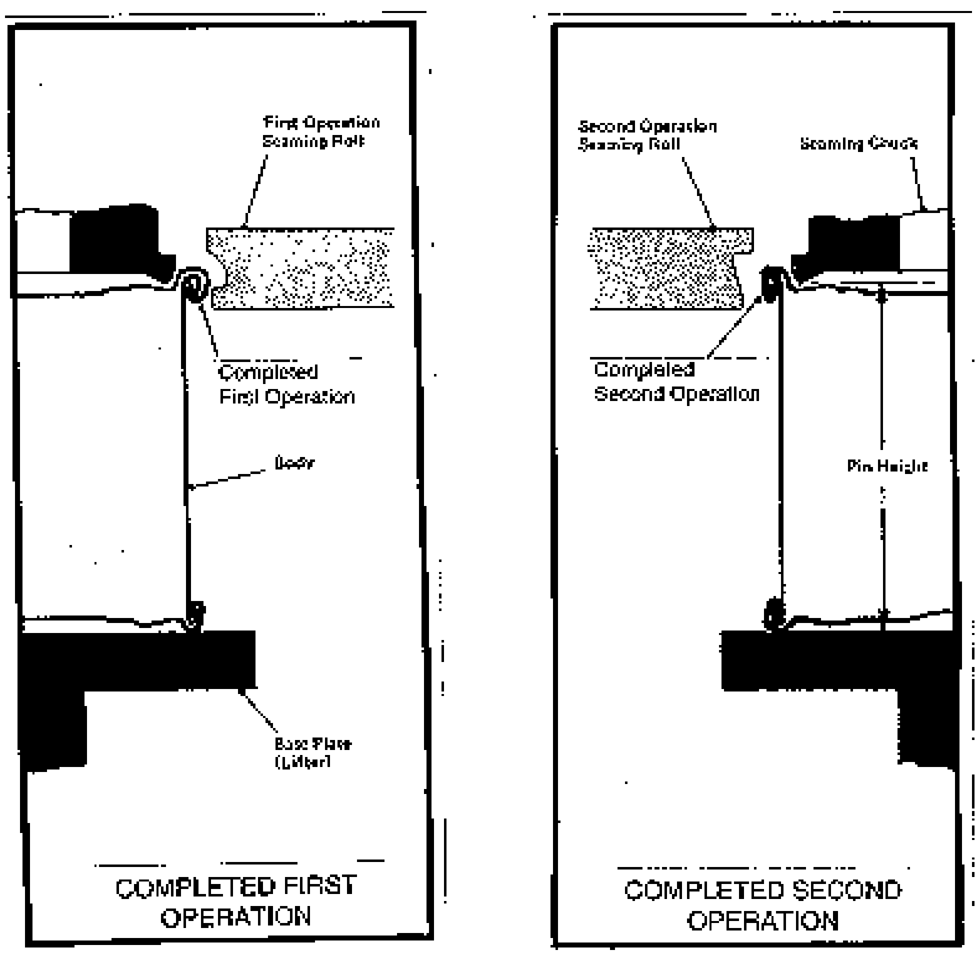

Figure 3.5.a - Basic Double Seamer Design

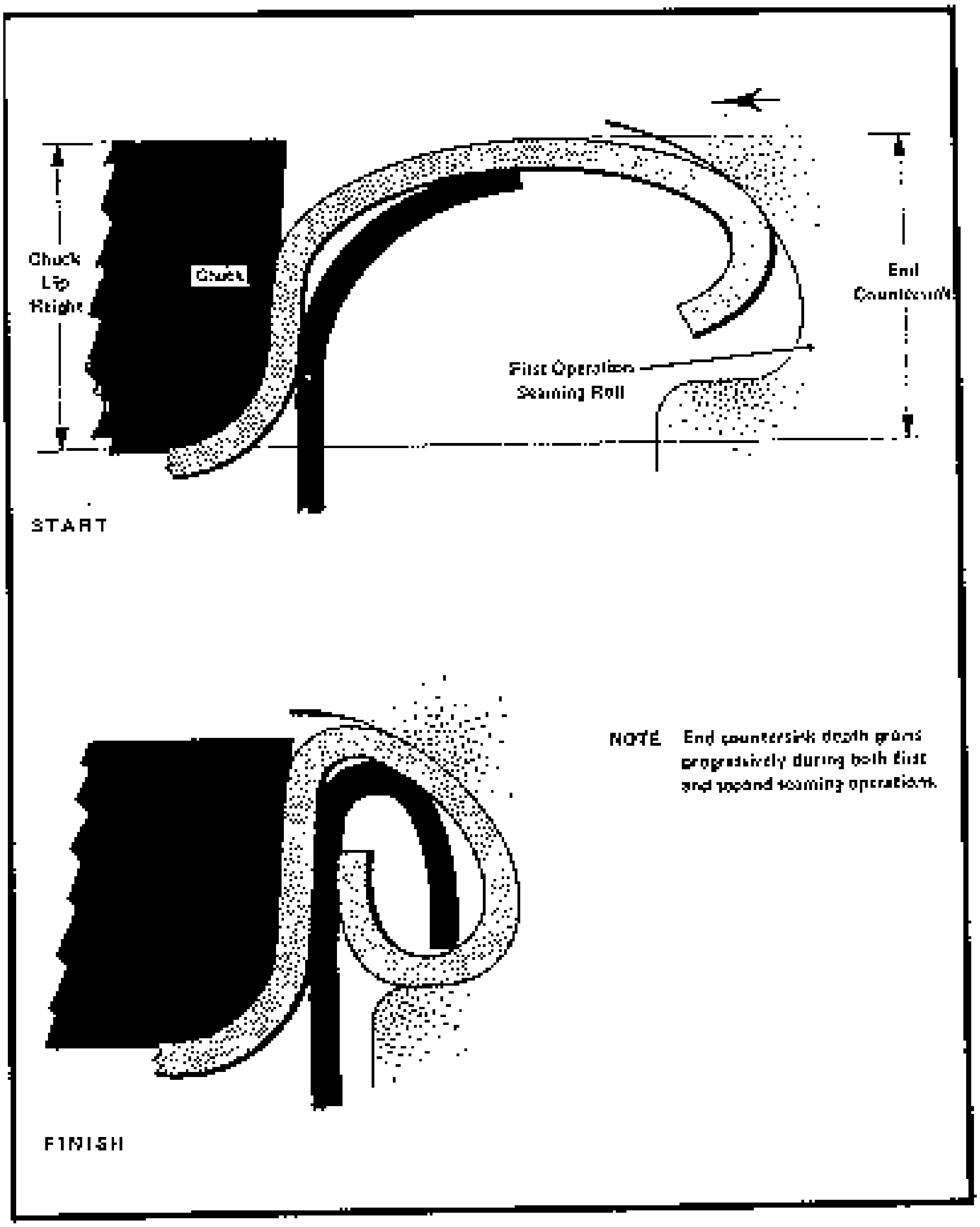

Figure 3.5.b - First Operation Seam Formation

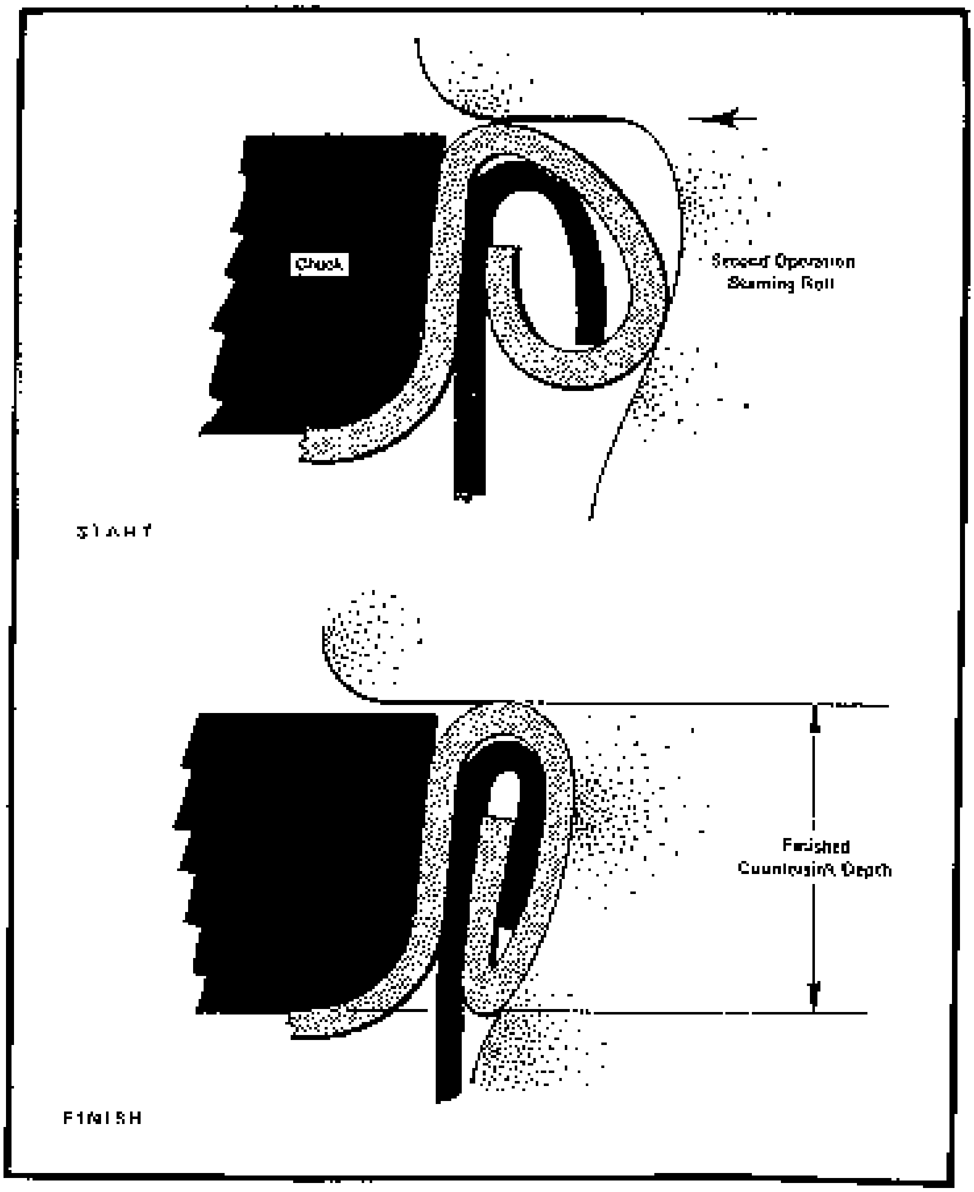

Figure 3.5.c - Second Operation Seam Formation

3.5.1 Can Closing Terminology

Some of the terminology associated with the can closing operation is as follows:

Base Plate - Alternate terms: lifter, lifter plate.
The part of the double seamer which positions and holds the can body along with the end against the chuck during the seaming operation.

Base Plate Pressure - Alternate term: lifter pressure.
The force exerted by the base plate as it holds the can body and end up against the chuck.

Chuck - The part of the double seamer which fits inside the end countersink. It acts as an anvil by supporting the end and the body against the pressure of the seaming rolls.

Clinching - The operation of bending the curl of the end under the flange of the body to hold the end loosely in place. This action, used in some seaming operations, is performed by a separate machine (clincher) prior to double seaming.

First Operation - The initial step in double seam formation in which the curl of the end is tucked under the flange of the can body so that the two are interlocked.

Knock-out - The part of the double seamer located in the middle of the seaming chuck which pushes against the seamed end, ejecting the can from the chuck upon completion of the second operation.

Pin Height - The distance between the highest part of the base plate and the lowest part of the chuck in their seaming position.

Second Operation - The finishing part of the seaming operation where the hooks formed in the first operation are ironed tightly against each other forcing the sealing compound into the voids to effect an hermetic seal.

3.5.2 Double Seam Integrity Factors

The prerequisites for achieving good double seam integrity are:

1) properly formed and undamaged cans and ends;
2) the absence of other material in the seaming areas (e.g., product, excess solder or sealing compound, foreign material);
3) the presence and proper placement of sealing compound in order to fill the prime sealing area which will prevent leakage;
4) the proper mechanical interlocking of the body flange and end curl resulting in overlap; and
5) the compression of the interlocked flange and curl to form the body hook and end hook which are tightly interlocked.

If the first three prerequisites are satisfied then final seam appraisal is based on the latter two prerequisites, namely overlap and tightness rating/pressure ridge. The various measurements of the double seam that may be taken aid in a decision that the overlap and tightness will be sufficient to ensure the sealing compound is properly held under compression.

(a) Overlap

The body and end hooks must overlap sufficiently to ensure that the sealing compound is properly held under compression with the correct seam tightness. The length of the overlap varies with the dimensional guidelines for each seam. In each case, however, a minimum length is provided in the accepted double seam guidelines. See Table 4.1.5.

Percent Overlap - This is defined as the ratio of the overlap length (A), relative to the internal seam length (C), expressed as a percent. See figure 3.5.2.a.

$$\% \text{ Overlap} = A/C \times 100$$

Body Hook Butting - This is another method of quantifying the void in the prime sealing area in the double seam. It is defined as the ratio of the internal body hook length (B), relative to the internal length of the double seam and is usually expressed as a percent (percent body hook butting), see figure 3.5.2.a.

NOTE:

Body hook butting may be taken separately as one of the factors of the double seam integrity. Body hook butting calculations cannot be substituted for overlap measurement in evaluating a double seam. Body hook butting should be considered as one of the factors that may be used for assessing double seams; overlap, tightness and pressure ridge are other important factors. The length of the body hook in relation to the internal length of the seam must be sufficient to ensure that it is embedded in the lining compound. Experience indicates that a minimum of 70% body hook butting is required to ensure an adequate seal.

Formula for body hook butting - using optical method for measurements:

$$\% \text{ Body Hook Butting} = B/C \times 100$$

Formula for body hook butting - when doing a tear down:

$$\% \text{ Body Hook Butting} = \frac{BH - 1.1tb}{SL - 1.1(2te + tb)} \times 100$$

Where BH = Body Hook Length (use the minimum of the readings taken at points of routine measurement Fig. 4.1.2.a)

tb = Body plate thickness
SL = Seam Length
te = End plate thickness

Double Seam Length - Alternate terms: height
This dimension is an indicator of overlap in that as the length increases, relative to the ideal, the overlap is usually reduced. Seam length is partly dependent on the roll groove profile and the degree of seaming roll wear.

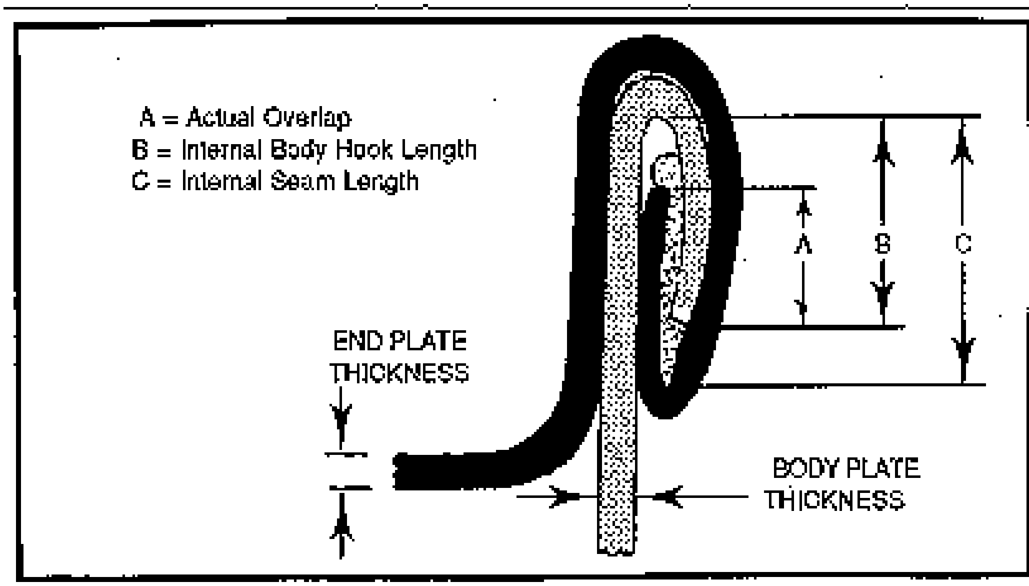

Figure 3.5.2.a - Overlap and Body Hook Butting

(b) Tightness

The double seam must be sufficiently tight to hold the sealing compound under compression but not so tight that the metal plate is deformed with the possibility of metal fracturing.

There are two aspects that must be taken into consideration when judging seam tightness:

1) the tightness rating, which is a measure of the degree of wrinkling of the end hook; and
2) the pressure ridge.

Other external double seam measurements which indicate proper seam tightness are:

3) double seam thickness;
4) crossover thickness; and
5) free space.

1) Tightness Rating

When straight edges of plate are folded over on themselves, the fold is smooth. When curved edges are folded over on themselves, the fold is not smooth, i.e., it is wrinkled. The degree of wrinkling increases as the radius of curvature decreases. When fitting an end that is either partly or totally round, wrinkles form on the end hook in the first operation. The degree of wrinkling is reduced when the double seam is compressed in the second operation. The double seam must be sufficiently tight so that the free space is low, but not zero. This will ensure that the sealing compound is properly held under compression.

The tightness rating is a measure of the degree of wrinkle left on the end hook on the completed double seam.

2) Pressure Ridge/Pressure Area

The pressure ridge or pressure area is an impression on the inside of the can body in the double seam area and is formed by the second operation seaming roll pressure. In suitably tight seams the impression should appear continuous and uniform along the entire periphery. The size of impression may vary from a faint continuous line approximately 3 mm below the body hook radius, to an obvious 3 mm wide area of compression (pressure area) in which the appearance of the body is slightly altered. The degree of impression is dependent on the body plate temper, the can size and style, and the double seaming equipment used.

The presence of an excessive pressure ridge should be avoided. There are occasions when a pressure ridge may be faint, absent or excessive but the seam may be satisfactory when other parameters are measured. The presence of a pressure ridge will depend on chuck design and temper as well as the type of container.

3) Double Seam Thickness

This dimension is an indicator of double seam tightness. For a given can, the thickness range should not exceed accepted double seam guidelines.

Since end and body metal thicknesses sometimes vary on the same container, the actual thickness of the five layers of metal would be calculated as:

(2 x body metal thickness) + (3 x end metal thickness) = Calculated double seam thickness (with no sealing compound)

In order to allow for seaming compound and normal seaming characteristics, a measured double seam thickness should not exceed this calculated thickness by more than 33% in the prime sealing area. The measured double seam thickness should not exceed the calculated double seam thickness by more than 33% in the prime sealing area.

4) Crossover Thickness

This is the maximum thickness of the double seam where it intersects the lap.

5) Free Space

The difference between the measured seam thickness and the sum of the five thicknesses making up the seam. This calculation may be used as an indicator of tightness; however, it must not be used to replace tightness rating.

Free space = seam thickness - (2 x body plate thickness + 3 x end plate thickness)