

TOTAL QUALITY MANAGEMENT FOR TENSION MEMBRANE

FABRICATION & ERECTION

MIKE URE

DIRECTOR

STURCTURE FLEX LIMITED

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Satisfied Customers. Can we all say that the end result of every job we have done is a satisfied customer. How many times has the steel fabrication, the cable supplier, the engineer been blamed for delays or rework because of incorrect fit. Excuses are of no consequence to the customer who wants a membrane structure fit for his purposes, erected on time.

Our industry is small, novel and slightly intimidating to many of our potential customers and to those who propose Fabric solutions to them. Growth in our industry will be greatly enhanced by practical solutions and designs, fabricated and erected in a thoroughly professional manner.

There are disappointing structures in Australasia and there are disappointed customers. Within our industry there are gripes that "so and so" does poor work or that "Sam Smith" buys jobs. This sort of back stabbing creates apprehension.

The solution is positive! Bring ourselves up to a recognised standard and sell that benefit to potential clients. The "so and so's" and "Sam Smiths" will either lift their standards or die.

Recognised Quality Standards are relatively new. In 1963 the US Military tired of buying bombs that didn't bang required suppliers to comply with a Quality standard named MIL-Q 9858 and that got the ball rolling. Numerous 'Guru's' have offered their formulae for Quality Management but the Canadians set up the first National Quality standard called CSA 2299 in 1975. The British Standard BS5750 came out in 1979 and the Australian standard AS11821/2/3 in 1985. The first ISO standard the 9000 Series was first published in 1987 and this has now been adapted by 40 countries including every trading partner of New Zealand and Australia. The Australian standard AS3900 and the New Zealand standard NZS 5600 both replicate the ISO 9000 series.

It is fascinating that such a vital business ingredient "Quality" has taken so long to be set out in a formal manner.

Naturally every business has to have some Quality Management, as without any work instructions or completed order forms the business could not exist.

Structurflex believed itself to be an efficient organisation producing quality goods, after all we already held a Design Mark and Design Award for one of our products. Demand from potential customers in particular the Military forced us to investigate formal accreditation to a recognised standard.

We approached "Telarc" The New Zealand Accreditation Authority for Quality Assurance and decided to aim for ISO 9002 (production level) and later on to ISO 9001 (design level). Elated by the prospect of proclaiming to all the Quality Assurance we offered we rushed to compile our Quality manual only to realise how deficient we were. Deflated we set aside the manual writing and began the grind from the bottom up. Setting out written work procedures for all of our products, writing accept/reject criteria, finding all of our drawings and putting them into one controlled system, writing a document control policy and eliminating all of the superceded documents from the system. On and on!

That was twenty months ago, and we hope to be accredited before Christmas. The twenty months work has resulted in a more efficient company a more productive company, our rework level is greatly reduced, and we are able to confidently delegate responsibility. Our staff feel more involved.

The manufacture and erection of Fabric Structures are crucial procedures. The end product has to fit tight strength and dimension tolerances. Quality is essential - how do we build it in?

The first hurdle to overcome is Management responsibility. Most of us here today are "The Management" and we readily profess quality -committing to quality very different! My experience over the past 20 months is that problems grow from the management down not the shop floor up.

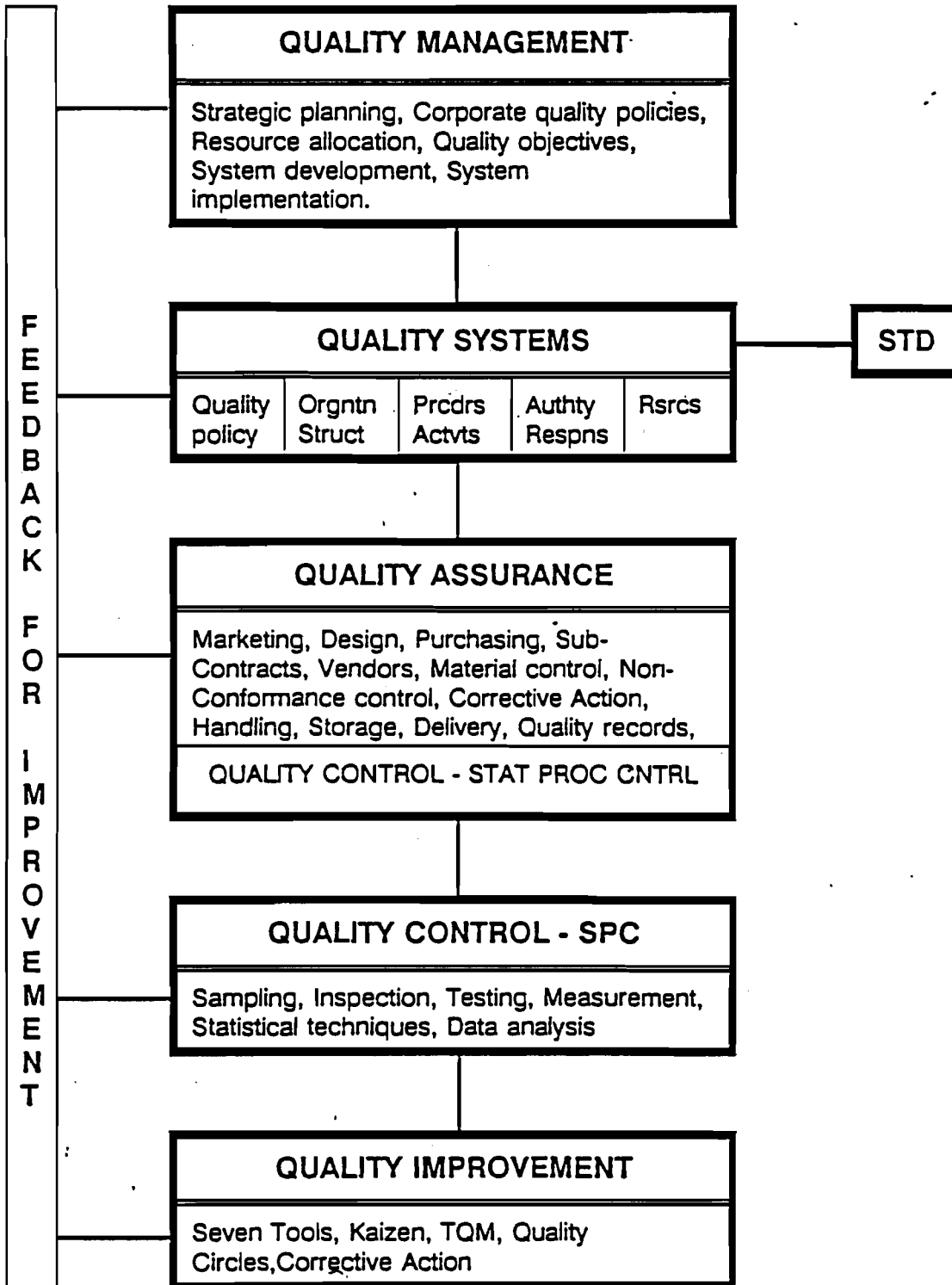
A Quality Management programme begins with a written Quality Policy signed by the highest authority. Resources must be allocated to develop and implement the plan, develop and implement the systems.

The Company infrastructure must be set up to handle the day to day requirements. Telephones must be answered, filing done, letters typed, data fed into computers. A formal structure must be documented clearly showing reporting paths. Job descriptions should be written for all managerial and supervisory staff. A job description must be written for the Quality Manager.

A formal system for reviewing and auditing the policies and systems of the company should be set out and review documents retained.

What is Quality Management ?

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DOCUMENT CONTROL

The company must establish and maintain procedures to control the authorisation and issue of all essential documents. These documents comprise all of but not exclusively drawings procedural instructions, computer files and the Quality manual. To put it in simple terms everyone must have ready access to needed documents nobody must have superceded documents. Quite frankly this is a can of worms and considerable thought is required to devise a simple practical system that meets the criteria.

PURCHASING

No one can make a satisfactory structure from unsatisfactory materials. Purchased materials must comply with specifications and arrive on time. A documented system must be set up to make it happen. A purchasing policy that ensures only competent reliable suppliers are used not the cheapest and incoming goods must be inspected.

PROCESS CONTROL

This will be covered later in paper.

INSPECTION & TESTING

How long are your tape measures? We didn't know, we had variations from tape to tape and did not know which one was correct. In New Zealand there is no approved authority that will certify a 20 metre tape as correct. The fabricator must establish documented procedures for checking all measuring and testing equipment.

NON CONFORMANCE PRODUCT

Don't let it get used set up a documented system that won't permit its use.

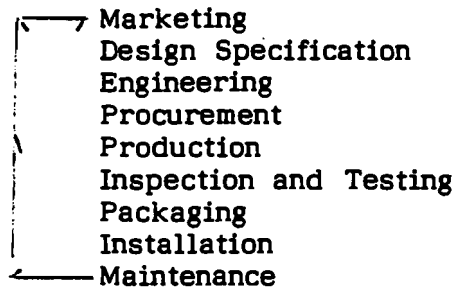
STAFF TRAINING

The last requirement of ISO 9000 says identify staff training needs, provide the training and maintain records of it.

After complying with all of the above the fabricator has reams of quality records which he may from time to time need to access. A plan must be made to establish procedures for identification, indexing, filing, maintenance and inspection of these records.

Now that we have established the infrastructure we can start work.

The Principle of the Quality system is the Quality loop which applies to and interacts with all activities pertinent to the product and involves all phases from initial identification to final satisfaction of customer requirements and expectations. This Quality loop looks something like this for a fabric structure.



Let us look briefly at each function on this loop as they relate to the fabrication and erection of Fabric Structures.

1/ Marketing The fabricator may be involved with the end user or as a fabrication contractor only. Regardless he needs to accurately determine his customer requirements by a review of the contract or market needs and to include an assessment of any unstated expectations held by the customer ie Can the job be done, can it be done on time, can it be done profitably, will the customer be satisfied. The format of this contract review should be documented and the results retained.

2/ Design Specification & Engineering In some cases the fabricator will have a design and build contract, in other cases he will be given the specifications to work to. Regardless, details need to be reviewed under a formal process. Can the specification be met. Can the structure be erected as designed. Are the tolerances of the fabric and tensioning equipment adequate to cope with the permissible tolerances of the steel.

3/ Procurement Can material meeting the specification be obtained, and obtained within the required time frame. What Quality specifications are required from the suppliers. Are the suppliers established and reliable. Will they supply compliance certificates.

4/ Production What are the fabricators standards for the production of tension membranes. What evidence is there that these standards are maintained. We have included with this paper a copy of our minimum specifications and our process check sheets that cover set out, cutting and welding of every panel in a structure. Completed sheets are retained in their original form.

- 5/ Inspection & Testing The responsibilities and the authority of various staff must be clearly defined. A person who is responsible for a procedure is the person who is implementing that procedure. The person with authority for a procedure is the one who has the right to give commands, enforce compliance and make final decisions. I have been told on good authority that the assembly line worker at 'Honda Cars' in Japan has the authority to press the button and stop the assembly line if the product he is responsible for does not comply with the given specification. Now that is delegation! I have always found it very difficult to delegate and it was only after embarking on our quality management programme that I found why. I was hesitant to delegate because I was not sure that the delegates would make the right decisions. How could I expect them to make the right decisions when the right decision was what I was thinking. Obviously, if I wrote down the process by which I reached a decision I could then delegate the authority. I know this sounds very obvious but it was a big break through for me and is exactly the requirement of the ISO standard. About fifty drafts later out came our accept/reject criteria for products manufactured by us. For fabric structures our current accept/reject criteria are:

AR1 CONSTRUCTION DETAILS

AR1 b Destructive testing of sample welds as prescribed for the job. These samples shall be a minimum 600mm long with a 300mm section of each delaminated to test for appropriate weld strength. The samples for the completed job shall be bagged and labelled and stored for ready referral during the life of the product. No product shall be manufactured until 100% welds are obtained.

AR2 VISUAL APPEARANCE

AR2 b The inspector shall be aware that these goods will be seen with backlighting. The inspector shall satisfy himself that the fabric has been passed over a light table prior to fabrication and that fabric with defects exceeding the permitted standard has not been used.

Defect

Any spot, stain, dirt or foreign matter (contamination) that will not pick out. Size exceeding 3mm diameter.
 Any coated over knots that will not - leak -size exceeding 3mm diameter.
 Any blisters (Domed or craterised)
 Any wrinkle that can not be removed by manual tension.
 Any visible scratch or abrasion.
 Any non-uniform embossing
 Any abnormal or strong odours.
 Knots not coated over (bare)
 Any hole, cut or tear

Noticeable uneven coating or unbalanced face to back coating
 Any delamination
 Any uncoated or miscoated area
 Colour off shade, streaked, spotted or discoloured (Burnt)
 Folded over, scalloped or wavy edges precluding lay flat of fabric
 Width less than minimum
 Any tackiness (fabric must unroll readily)
Rejected Goods must have defective panels replaced

AR3 DIMENSION REQUIREMENTS

AR3 b The products size is critical. A check sheet will be provided and must be completed. Where not specified tolerances are $\pm .1\%$

Rejected Goods shall be reworked and reinspected.

AR4 SPECIAL REQUIREMENTS

A specific written AR instruction will be provided with the job sheet.

5/ Packaging Written folding and packaging instructions need to be developed for each structure that will result in the goods arriving at the customer site in good order. Considerations need to be made for transport to and storage at the site. Weight and size of the package and available methods of handling must be addressed.

6/ Installation The whole sequence of installation must be documented from arrival at site until completion, who does what, how many who's, plant requirements, tool requirements, safety regulations, environmental conditions, Insurance requirements site measurements etc. "What if" contingencies must also be documented! What if the wind speed exceed the specified level, what if the membrane is torn, who has the authority to make site decisions, what are the limits of that authority.

7/ Maintenance Specific details of maintenance requirements emergency phone numbers, and emergency procedures should be documented and lodged with the client.

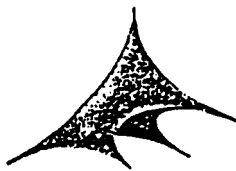
From the first enquiry this quality loop must be put into a documented review process and the results must be positive before the potential contract is permitted to move to the next step ie. you are wasting your time and the clients time if you carry on discussions on a job that cannot be erected because of a technical flaw, the technical flaw must be overcome before proceeding further. These reviews should be structured to happen at fixed intervals and after criteria changes.

The twenty months of work on our QA programme has delivered nothing but benefit to our company and our customers. My enthusiasm for compliance with the standard has increased with every progressive step we have made.

The MSAA may like to consider making accreditation to ISO 9000 level 1 or 2 or their equivalents as prerequisites for the membership of any company or body designing or constructing membrane structures. This would make it a truly professional body.



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2.1 Work Area

The work area must be cleared of all obstacles, clear and free of all extraneous contamination. If multiple layers of fabric are to be moved on the floor a fabric skid must be used to protect the fabric from direct contact with the floor.

2.2 Fabric Storage

Incoming fabric shall be stored under cover at a similar temperature and humidity as that of the fabrication area.

All rolled goods, or partial rolls shall be clearly marked to indicate style and weight, and stored separate from unlike fabric.

2.3 Operators

Cutters and operators shall wear clean soft shoes whilst working on the material. They shall be skilled tradespersons, experienced in the field and capable of high quality work.

2.4 Supervisor

The supervisor for the work shall have experience in the fabrication of this type of structure and shall be responsible for fully implementing Quality procedures.

2.5 Handling

The fabrication shop shall be clean and dry. No scuffs, cuts, abrasions or permanent marks are to be made to the fabric. The material surfaces shall be clean, dry and folded prior to leaving the shop.

The fabrication area shall have smooth floors and only people wearing soft soled indoor shoes, which do not mark the fabric are permitted in the fabrication area.

2.6 Fabric Quality Control

The Fabricator shall inspect each panel of the material over a light table for any faults or marks which might be cause for rejection from the structure. Any such instances shall be reported immediately for inspection and determination of the appropriateness of these sections.

2.7 Production Planning

2.71 Prior to marking the supervisor will check all cutting patterns for discrepancies in adjacent panel lengths or other mismatches. A paper model should be made. Any queries that arise must be answered before marking and cutting begin.

2.72 The supervisor shall document the complete cutting, fabrication, handling, folding and storage procedures before fabrication. Calculations must be made as to weight and size of partially finished and finished structures to ensure that handling and folding is within the capacity of available space, plant, staff and equipment



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2.8 Fabrication Details

2.81 Patterns

Cutting patterns to be marked by a competent person experienced in marking. Marking to be checked by the Supervisor who will lay out spline and mark final cutting line.

All edges are to be marked and smooth curves are to be fitted prior to cutting. Panels shall be marked out to +/- 2mm accuracy and panel numbers and corner node numbers shall be marked for identification and registration.

All panel marks shall be made with a pen style which can be removed with a light cleaning agent which does not damage the fabric surface prior to folding and packing.

Any and all index points issued with the cutting patterns shall be used to obtain proper registration of panels during the welding process. In cases where index points are not issued with the cutting patterns, panels shall be assembled prior to welding and marked with suitable index points so that registration is assured.

2.82 Welding

All seams shall be high frequency welded to the dimension as indicated in the detail. All seams shall be 'shingle' laid in the appropriate manner to shed water away from a cut edge.

Care must be exercised in aligning and welding of adjacent panels and it is stated that wrinkling and puckering on one panel caused by the gathering of one side versus the other will not be acceptable. Tension of adjacent panels must be set up evenly on the bench before welding commences.

All welds shall be continuous without gaps, holes or trap pockets.

All welds shall be performed such that the entry of air or water into the seams of fabric is prevented.

The welding bar used shall be checked for straightness and any irregularities shall be removed by machining prior to the welding process.

Two (2) sets of sample welds shall be performed and approved prior to commencement of fabrication.

Prior to commencement of welding on each day, a series of test welds shall be performed to a minimum number of six (6) so bar temperature is elevated from cold to an operating level.

The machine settings shall then be adjusted following the performance of a further five (5) welds to a final heated setting requirement.

At any time where a cessation of welding activity of more than ten (10) minutes occurs, reheating and adjusting of the bar shall be carried out. The Fabricator should not use the same settings throughout so that heating of the bar causes excessive frying of the surface PVC.

Welds shall be performed so that no excessive bleed of PVC occurs about the edges of the weld. Any exposure of the substrate is a cause for rejection.



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2.83 Weld Testing

A properly performed high frequency welds shall be defined as one which when peeled apart, removes the PVC from one or both sides completely in an additive manner.

Tests shall be performed at two (2) hourly intervals or at the end of each seam and marked with the time, date and logged with data indicating the section of the structure being welded at that time. These samples shall be a minimum 600mm long with a 300mm section of each delaminated to test for appropriate weld strength. The samples for the completed job shall be bagged and labelled and stored for ready referral during the life of the structure.

Any errors in welding shall be immediately reported for a decision as to the method of rectification.

Welding of sections must always be undertaken from the inside of a structure towards the outside edge.

A log book of records shall be kept for each structure setting out all of the following information relating to checks, supervision, operator.

Refer Appendix 'A' attached.

All weld surfaces must be clean and free of foreign matter prior to welding. Cleaning materials used shall not damage the surface coating. Special care and attention should be paid to seams of more than two (2) layers. These must be treated specially and not pressed into the thickness of the remainder of the surrounding work with consequent extreme bleed of the PVC coating.

2.84 Hot Wedge Welding

No use of hot wedge welding will be acceptable unless specifically permitted. If permitted two experienced operators practiced in the welding of long continuous seams must do all welding. Even tensions must be achieved on adjacent panels with no puckering or folds. Maximum acceptable variation in length is .25%.

Where the wedge weld is stopped and restarted a visual check must be made in this area to ensure a continuous weld impervious to air or water. Test welds must be made to ensure wedge is given full width weld before welding of structure begins.

2.85 Reinforcing

Unless noted otherwise, all reinforced areas shall be fully welded. The fabricator shall weld such areas using specially made welding bars to minimise the number of strikes used to block weld. Unsightly and distorted finishes will not be accepted. Shrinkage in the weld zone is to be minimised by proper set up and machine adjustment.

2.9

Question

If in doubt ask for specific instructions before proceeding.

