Training

of

bonders, supervisors and inspectors

2014-2015

5th Qatar Materials Forum January 2017

Location: University, Doha

By J. Steen MSc,
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Content

Front page photo, courtesy: Jishnu Narayanan

1. OIL-COMPANY's Khazzan gas project in Oman nears completion of phase one

Date:**24 October 2016, Courtesy OIL-COMPANY Website**
http://www.OIL-COMPANY.com/en/global/corporate/press/press-releases/OIL-COMPANYs-khazzan-gas-project-in-oman-nears-completion-of-phase-one.html

MUSCAT, Sultanate of Oman-OIL-COMPANY Oman announced that phase one of its massive Khazzan natural gas project is 80 percent complete and on track to deliver first gas near the end of 2017.

Located on a previously undeveloped desert site 350 kilometres south of Muscat, work on the Khazzan tight gas project began in 2014 and the completed development will eventually contribute roughly a third of Oman's natural gas supply.

The vast majority of the infrastructure is already in place including 56 kilometres of roads, several thousand metres of power lines (including broadband networks) and a 60 kilometre water pipeline from Hanya. Foundations and structures have also been put in place and equipment installation is in progress for the two-train central gas processing facility. The water treatment plant, waste management area and electricity substation have also been completed along with accommodation units for the construction workforce of up to 12,000.

Yousuf Al Ojaili, OIL-COMPANY Oman President, commented: "This is a world class project and with key infrastructure and many buildings now in place it is possible to see the real shape and scale of the facility emerging. Our aim is for first gas to be flowing by the end of 2017, representing a significant moment for Oman, with the gas that comes from Khazzan substantially increasing our country's overall supply and supporting greater diversification of Oman's industrial base. Reliable gas supplies are needed for the country's power sector and energy intensive industries. Also, this unique project is an excellent opportunity to develop Omani expertise in tight gas development and OIL-COMPANY is proud to lead this effort."

The Khazzan drilling programme is also on track with 38 of the 50 wells needed by first gas already drilled. More than 300 wells will eventually be drilled over the lifetime of the project. OIL-COMPANY has plans in place with extensions to be contributing 1.5 billion cubic feet of gas per day to the Omani economy.

As the largest investor among the integrated oil companies in the Middle East and North Africa, OIL-COMPANY brings a wealth of technical expertise in advanced seismic, hydraulic fracturing and horizontal well design. This deep technical knowledge is key to unlocking the vast reserves of tight gas which are contained in the deep, dense and extremely hard rock strata at Khazzan.

OIL-COMPANY Oman is lead partner in the project with a 60% interest. Oman Oil Company Exploration & Production holds 40%.

With national oil companies OIL-COMPANY is currently managing over 3 million barrels per day of oil and gas production throughout the Middle East.

Notes

- *OIL-COMPANY is one of the largest oil and gas companies in the world and has had an upstream presence in Oman since 2007.*
- *In December 2013, the Government of the Sultanate of Oman and OIL-COMPANY signed a gas sales agreement and an amended production sharing agreement for the development of the Khazzan Project in Block 61. The agreements were ratified in February 2014 in a Royal Decree issued by His Majesty Sultan Qaboos Bin Said.*
- *OIL-COMPANY is the Operator of Block 61 and holds a 60% interest. The Oman Oil Company for Exploration and Production holds a 40% interest.*
- *In February of 2016, OIL-COMPANY signed a heads of agreement with the Government of the Sultanate of Oman committing to amend the Oman Block 61 exploration and production sharing agreement (EPSA). Development of this additional resource is subject to final approval of the Omani Government and of OIL-COMPANY; both expected in 2017.*
- *Phase 1 is on track to deliver first gas by end 2017 producing 1.0 billion cubic feet of gas a day (bcf/d).*
- *Combined plateau production from Phases 1 and 2 is expected to be 1.5 billion cubic feet of gas a day (bcf/d), equivalent to a third of Oman's current total domestic gas production.*

Muscat, Oman

2. Introduction

OIL-COMPANY purchased from MANUFACTURER, Oman about 63 km GRE pipes. The pipes had the purpose to transport saltwater. The water was going to be used for fracking of the soil in the Khazzan project.

The diameters of the pipe were 10" and 12"inch.The joint-type was (conical conical) adhesive bonded. An estimate of 5250 joint have to be made for this project. The Pdesign is 46,2 Bar and the design temperature is 60°C.The pipeline is buried.

OIL-COMPANY is very reluctant in using GRP due to bad experiences. As there was no real other option than digging a canal it was decided to go for GRP pipes and fittings in this case. After a technical and commercial selection GRE pipes from MANUFACTURER was chosen.

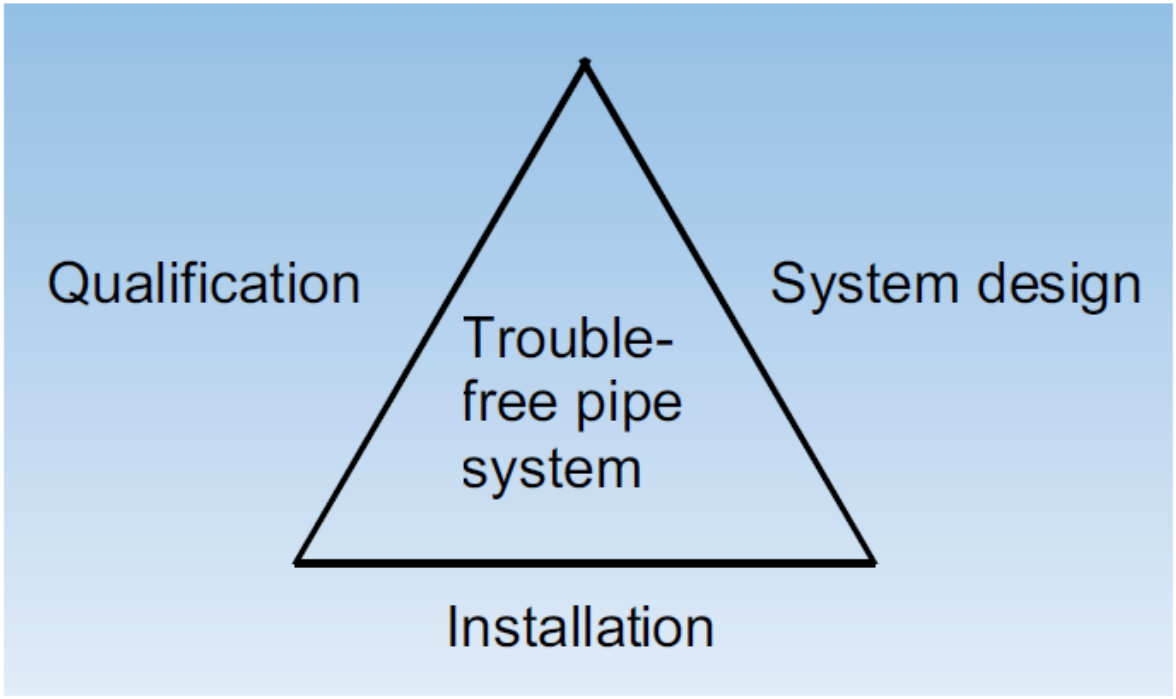
For a good trouble free system you need:

- A good GRP product (**qualificatio**n),
- correct engineering (**system design**)and
- a good **installation**.

Only when all three are done OK you obtain a trouble free pipe system.

Installation is often the neglected part. The purchase department goes for low costs. However installation is as equally important as the others: qualification and engineering.

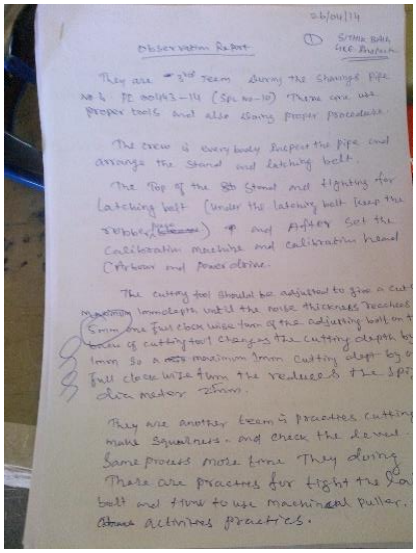
When it comes to installation I suggested to OIL-COMPANY that we do not go for a 2 days manufacturing certificate, but for a thorough training of 6-8 day.



For some 7 years a DNV GL certification was developed with end-users and manufacturers, more details you may find at the website of DNV GL: https://www.dnvgl.nl/services/grp-pipe-systems-specialists-58133
Some main issues of the DNV GL Personnal certifications are in a nutshell: independent exam no help during the exam and a tough theoretical part.

So the next request from OIL-COMPANY is more or less in line with the DNV GL approach. The main difference is that I do interfere with the training in this case.
On Request of OIL-COMPANY an inspection of a bonders training was performed at MANUFACTURER Oman. In 2014-2015 those inspections were performed.
In total 12 bonders, 3 supervisors and 5 inspectors were assessed. The pipes and fitting used had a diameter of 250 mm and a pressure rating of 46,2 bar. The hydrotest was executed at 122 bar for 1 hour.
A total of 24 adhesive joints were made and one laminated one.

During the training a few changes were made. The most important ones were: practicing with tools like grinder, flapper wheel and practice skills: applying adhesive, sanding. The joints were made one after each other, so that others were able to "learn , by watching". This was a deviation from normal practice where they are made at the same time.



Apart of the MANUFACTURER theoretical exam, another written exam had to be done under supervision of the OIL-COMPANY. The open questions were given at the first day and were practiced during the whole training. The questions for the bonder were in Hindi and for the supervisors and inspectors in English.

One special action during the exam: two inspectors had to stay one week more for gathering more experience.
The second and third team inspectors and supervisors had to write during the training reports, just obtaining some extra information about skills for the assessment.

About 6-8 days for the training per team was needed of which one day was for theory. There was a total of 3 teams with 6, 5 and 9 persons respectively.

For the practical part couples were formed with a bonder and inspector or a bonder and supervisor. The inspector

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Bonders qualification hydrotest 1 hour at 122 bar,
no leaks of the joint allowed.

For the practical part couples were formed with a bonder and inspector or a bonder and supervisor. The inspector and supervisor had to grind and flapper the spigot/bell as well, just to learn about the details and consequently what to check in the future (maintain angle, no shiny spots, spotless, blind side check, physical checking not from a distance, measuring insertion depth, gap, RH, Temp, check mixing adhesive, applying adhesive, distributed equally, check blind side again, massage it in follow the list with hold points) just face every aspect and the related difficulties. Do not rely, be strict, check!

After consulting the OIL-COMPANY office the title for the bonder candidates became: GRE adhesive bonder working with constant supervision. The reason is simple they have to gather more experience before one can call them a bonder.
The supervisors and inspectors do get, from MANUFACTURER, a certificate of attendance.

DNV·GL

CERTIFICATE OF COMPETENCE

Certificate number: CERT-GRPIN-20140528-10001-Rev.1
Exam date: 28 May 2014
Valid till: 28 May 2018

DNV GL Business Assurance B.V. declares that:

J. Steen

Date of birth: 6 December 1957
Place of birth: den Ham (Overijssel)

Has fulfilled the conditions to be certified as:

RTR / FRP / GRP Inspector
Glass reinforced Plastics (GRP/RTR) pipe installations, Competence profiles section, Attachment D2-2

Date of examination : 28 May 2014
Place of examination : Barendrecht
Country of examination : The Netherlands
Examination organisation : DNV supervision

This Certificate of Competence is valid only after the certificate holder has signed, as per examination date until 28 May 2018. The validity conditions of this Certificate of Competence are specified in the relevant standard, endorsed by the DNV GL Certification Committee of GRP pipes Attachment D1 and relates to ISO 14692. See reverse side for the information statement by employer and prolongation by DNV GL Business Assurance B.V. Additional information can also be stated in the column"supplementary remarks".

Thus agreed and signed,
The certificate holder:

Barendrecht, 14 June 2016
DNV GL Business Assurance B.V.

J.J. van Unnik

Signature

This Certificate is property of DNV GL Business Assurance B.V. Misuse will render this Certificate null and void. DNV GL Business Assurance B.V. P.O. Box 9599, 3007 AN Rotterdam, The Netherlands, E-mail: vakbekwaamheid@dnvgl.com.
DNV GL Business Assurance B.V. is registered at the Dutch College Bescherming Persoonsgegevens, nr: m1012137.

DNV GL RTR/GRP Inspector's certificate

3. Length of spools

The history for training is to take the samples as small as possible, where in practice the pipes are really 12 meter long. As the manufacturer makes anyhow 12 meters and the enduser is anyhow paying for those 12 meters then use as much as possible. So I was asking for longer sections, nice for practicing and you can still handle them.

For training purposes the length of the samples have to be longer, at least 3 meters each, it is recommended to change that in the end users GRP spec's procedure. For long straight lines it makes more sense to work with some longer pipe pieces The end users are anyhow paying for the pipe.

- .

Small samples, during manufacturing training mostly the only this small size and then with quite some people per joint.

Small samples does not give a real feeling.

Large length samples and realistic diameter compared to the actual installation.

Threaded joint: Nice practice how to do the assembly “basics”

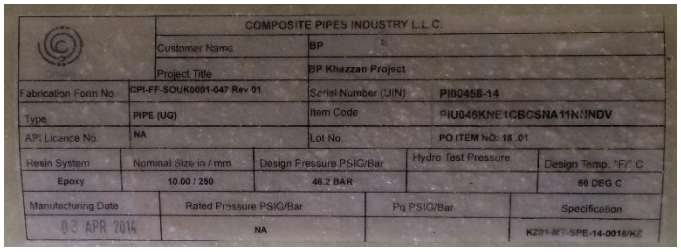
This is reality, full scale and under an angle, this is part of the exam. You can see some youtube video’s regarding this assembly, use link: www.grpcenter.com.

4. Theoretical part

- 1 day training theory.
- Written exam for the bonders in Hindi,1 in Benghali and for the inspectors and supervisors in English
- The open questions were:
  a. Describe bullet point wise the adhesive assembly procedure
  b. Describe bullet point wise handling and storage
  c. Describe bullet point wise trenching and backfilling
  d. For inspectors and supervisors: describe the critical factors of adhesive bonding.
- The objective of the open question is that they focus on these parts and learn by heart, they were practicing every day for these questions. During the 1hrs and 15 minutes all bonders were writing continuously and concentrated.

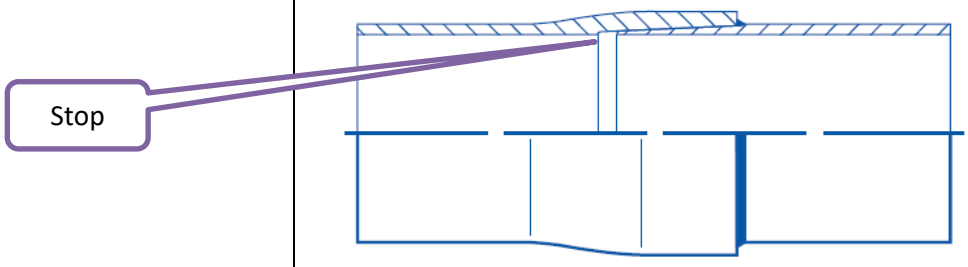
5. Practical part

The following is to give an impression

Check pipe: marking, damage etc. Quite sometimes marking is missing	
Shaver/Calibration machine Shaving a spigot • Alignment • Nose thickness • Setting of the shaver correct angle • Cutting blades • Not touching surface • Use clean gloves • Cover the spigot with a clean paper and use tape for fixation • **It looks all simple, but the next day everybody has forgotten about everything.**	

- Cover the spigot with a clean paper and use tape for fixation

- This is NOT good.

Flappering a spigot Practicing on scrap, this is not an easy job. To do that accurately is difficult, so the candidates practiced quite much. Even scrap was used for practicing sanding. Important is to maintain the cone, when not carefully done the part at the nose end becomes a cylinder. The time between applying adhesive and sanding must be smaller or equal 1 hrs. And not a cricket game.	
Cutting/shortening spigot with a grinder Learn to cut a spigot and do it square. Why? If shaved too much and nose thickness is not OK e.g. too small then the insertion depth can be too much and will hit the stop and will go over it. That will create a huge air pocket. So a check here is most important. This shall be an holdpoint. Let it check by the inspector! Without measuring it is always OK which is not ok. **One of the key factors to success of the installation.**	
	

Remarks:

- Bonders must knowhow to measure the gap: during dry fit and after assembly . Normally this will be done by the FSE and when he is not there or when he is not checking this can lead to a failure. Reason: If you pull the nose over the stop then it will be pushed inside and the airpocket is there. Rupture of the joint can occur now.
- I wanted that they all know what to measure and what to check and how to check. For me this was a serious holdpoint during the training!!
- However in the procedure another issue did pop up: what is the allowable squareness of the spigot end in combination with the insertion depth.
- The ISO 14692 says 3mm. Now suddenly the scribe becomes important. If you would have measurement at the minimum this can then make a difference with maximum side of 3 mm.
- This contradicts with the requirement after make up of the scribe shall be between 1 and 5 mm, dry fit between 5 and 10.. So squareness tolerance has an influence and set to maximum 1 mm and additionally the insertion dry fit shall be between 8-10 mm. Then there is some room for squareness tolerances.
- Other manufacturers takes a gap between 10 and 15 mm then this problem is solved in another way.
- So it sounds as a minor issue but it is a major issue over and over again per joint and in both project 10000 ! times.
- The danger with 10-15 mm is maybe you pay less attention, the issue stays the same.

Environmental check like Relative Humidity, ambient temperature and as shown here temperature of the pipe pieces, spigot and bell. In the sun these pieces can become very warm.	
Dry fit Measurement Insertion depth / checking gap before bonding. The rule of thumb if the gap is A mm during the dry fit then the final gap after assembly is: A – 5 mm up to A – 7 mm	
Here the final gap is 4 mm.	

Alignment, always important that the pipe pieces are fully aligned, centered etc	
Cleaning with acetone, last step before applying adhesive	
Mixing adhesive for 3 minutes	
Applying adhesive, an uniform layer must be applied by the bonder, 2/3 of 2 packages must be applied on the spigot and 1/3 of 2 packages on the bell. The pipe is assumed to be fixed and not allowed to turn. Check blind side!	

Final insertion of the pipe piece.
The insertion must be stress free, well aligned and fully centered.
Take care:

- **that piece 1 is proper supported and level**
- **that the piece 2 is correctly supported during make up etc.**
- **It is NOT TRUE that a conical joint will centre itself.**
- **It MUST be centred upfront. So that no adhesive is pushed off during make up.**
- **Centring is of major importance**

Pulling the two pieces together.

Check level and check the gap (required to be between 1 and 5 mm)

Check pullers keep the tension. If tension suddenly releases do the joint again.

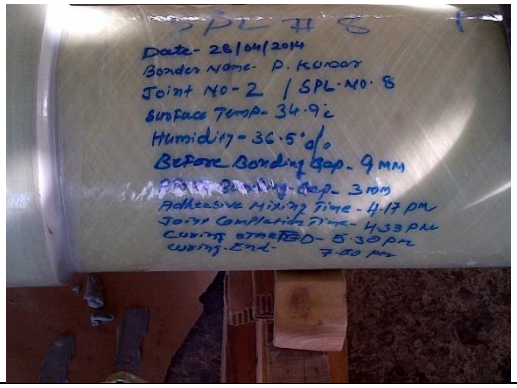
Put some adhesive under a tape on top of the joint for checking Tg or better has the heating blanket functioned well.

Every candidate was solely responsible for this last joint, stub-end, of a spool.

All others silent.

Gap width can be seen and measured.

Gap width after assembly

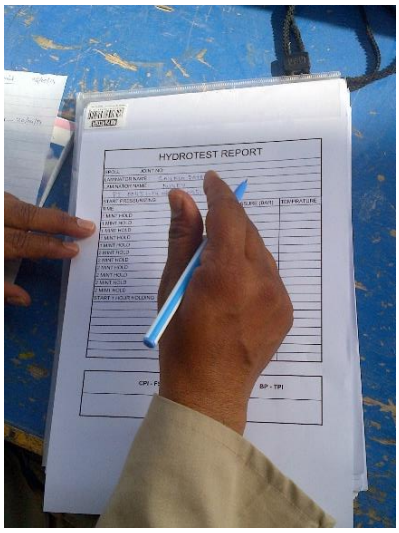
Curing Joints/pipes in the back curing middle joint heating blanket is visible. Pipe spool in front, curing in progress, heating blanket at the inside and bonder is checking the temperature. See the temperature control equipment (left bottom)	
Heating blanket • Wait till the adhesive has gelled so much that it is not sticky anymore. • Apply heating blanket and is all covered. Switch on and control temp during the 2 hours cure every ten minutes. • When curing is finished swith off electric and wait 1 hour for cooling down (I have no idea why) before releasing the pullers.	
Administration, a few things have to be recorded according the ISO 14692, this can be written on the pipe but also on a designated paper. **Every candidate could write this down, they were learned how to do that in English, in the beginning with translations.**	

1.	Bonders name	
2.	Date	dd-mm-yyyy
3.	Ambient Temp/object temperature	°C
4.	RH	%
5.	Batchnumber adhesive	
6.	Batchnumber Heating blanket	
7.	Gap dry fit	mm
8.	Gap after make up	mm
9.	Adhesive mixing time	Hrs:min
10.	Joint completion	Hrs:min
11.	Start curing	Hrs:min
12.	End curing	Hrs:min

Hydrotest of the spools made.

Spool contains 2 adhesive bonded joints. Normal pipe bell/spigot in the middle and one stubend. (in this picture at the end with the mounted blind flange)

All hydrotests were successful.



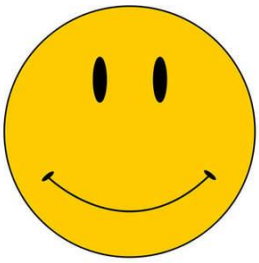
6. Spoolbuilding

During the second project of OIL-COMPANY spoolbuilding was also incorporated. As spoolbuilding require others skills like: precise alignment, leveling, maybe angles, consequently correct supporting and applying straps it was decided to make 2 spools. There were two teams and therefore enough joints in every spool to be responsible for. Both teams had a contractors supervisor, fully in charge.

Most of them just installed the 63 km above described line, so adhesive bonding skills were top level.

One spool ready one spool in progress: Spools contain: 2 stub-ends, elbow, tee, laminate. The dimensions should be according a drawing. Nice assignment.

The installation included finally about 4600 joints and again no leaks!!



Elbow

Tee

Some stages during the spoolbuilding.

Leveling

Both spools passed the hydrotest.

7. General view about candidates

Candidates

- In almost all teams present during the training candidates came directly from India.
- The candidates had little experience or not at all with tooling or with the material.
- Many languages in one case more then 5, was finally not an issue
- All were willingly to learn excellent attitude.
- The bonders without any exception did speak an English in which not the simplest communication was possible.
- Without translation communication was therefore impossible.

Candidate inspectors and supervisors

- Mostly has been supervisor in another job.
- Out of the ranks
- Only one had experience.
- Excellent attitude

Only a few failed.

Be aware the candidates called the training a military boothcamp.

8. Observations and Recommendations

- Start with safety, LMRA, mostly 50 to 100 % of equipment is not OK, wiring / inspected / beyond expire date
- Start with learning the use of electric equipment. 4 hrs, for some no idea about equipment, safety major importance.
- Decided to make every joint one by one. Joint per person, let the others watch, they learn from every joint, let them write down their observations, do they see mistakes?
- in one case there were so many languages present that 2 guys were running 2 days behind no idea what was told.
- Order long pipe pieces simulating more or less the handling of a pipe.
- Sanding is not easy with a flapper wheel and has to be practiced.
- Sanding and cutting spigot has to be practiced as well.
- Remark: when sanding a scrap surface: It is mandatory that the surface is fully prepared till it is grey and dull. "A FSE said this is enough sanded" although the surface was not ok, that is wrong. You show it once not completely correct, they wil do in reality this wrong way. Be strict and perform your actions according the procedure.
- An assembly procedure can also contain a flaw, however. Manufacturers are improving.

Theory conditioning

- Keep repeating the sequence of how to make a laminate or an adhesive bond over and over again. Do the same with handling, transportation and storage. In a few days they know all. Mostly I set them in a circle, everybody has to mention 1 step, again and again. When they are doing nothing one of the seniors (GPS supervisors) can practice with the candidates.
- The open questions were given upfront, they have to know it anyway:
  - Describe bullet point wise the adhesive assembly procedure
  - Describe bullet point wise handling and storage
  - Describe bullet point wise trenching and backfilling
  - For inspectors and supervisors: describe the critical factors of adhesive bonding.

Advantages training in this way, quality you build together

- Everybody knows how to make a joint, knows exact sequence, , in the field they can correct each other.
- By slowing down in speed everybody has the time to apprehend the knowledge and get used the material
- Every bonder has to make a joint by himself without help
- The candidates have to learn to make the correct decisions in the field, failures during training are most welcome. An expert is somebody who made all failures!! Let them do it completely wrong.

In the field project praxis

- OIL-COMPANY let every bonder make a joint. Till a string was made with all bonder joint and that string was tested at 1,5 times design pressure no failures.
- What's done here is completely different from what is usually done in the Middle East, however what are the consequences:
- First job: 5250 joints made NO leaks

Consequences

- Although OIL-COMPANY did not want GRE in the beginning but due to the succes, they went for the next job 4600 joints made NO leaks
- Now OIL-COMPANY went for the third job with GRP.
- So with a real professional workforce you can create a market for GRP. So there should be interest from manufacturer and end user.

9. Recommendations regarding training and supervision/inspection

- **It is strongly recommend to select/examine always at the gate your bonders (even "experienced" bonders or so called manufacturer prefab bonders)and not at all rely on a manufacturers certificate or something else.**
- Select at the gate: FSE, Supervisor, Inspector. Even certified by third party, manufacture or what so ever. Make criteria for selection or acceptance manufacturer FSE/Trainer and examine that. Do not be nice and weak but strict and firm. Keep monitoring that.
- Review very thoroughly the assembly procedure, even the smallest deviations are not allowed. The procedure has to be used for the 1000 hrs testing.
- Certify training and certify trainer. Repeat that every year, do that together in Qatar for all end-users.
- You need as well: well experienced leaders/supervisors, to be checked and certified as well, at the contractors side.
- Be present during training, know where to look for. Do not be so easy on your own inspectors.

Example1:
In the OIL-COMPANY case the contractor send the FSE away from the installation as he wanted always to introduce "improvements" the contractor refused to do that or he should sign for the change. The FSE did not do that. He can be a risk. Then the "smart inspectors of the end-users" had their own ideas about improving the speed, stop that. Just follow exact the procedure there are no short cuts.
Keep in mind that this assembly procedure is used for the 1000hrs test, so if you want to deviate then test it again!!

Example 2:
Oil Company Qatar, a PVC GRVE dual laminate a welder created already the problems. It will be most likely not a lonely one. Select the welders, make an examination where they make by their own a difficult weld, not a plate but a complicated one. Minimize this risk.

Example 3:
Another example is a case where a bad joint was made. The wrong type was installed, besides that the pipe was not supported well (Engineering.). The failure of the adhesive joint was bad workmanship. Select the bonders at the gate.

Three major important projects where one guy can wrack your whole piping system.

Training
Teaching is important, monitor frequently the training by an real experience inspector. Manufacturing training is insufficient.
I do not find the above mentioned issues back in the specifications like the ISO 14692, it can be a 2 days course. There is benefit for all to do it differently.

- End-users get a more reliable piping system,
- End-user benefits from GRP (low maintenance etc) and building up confidence in GRP
- For the GRP manufacturers the market will increase

10.Suggestions:Spoolbuilding

- It is recommended to hydrotest spools, when possible prior to installation, however you already may have decided that. When there are plain ends, these pipe are kept a little longer a flange is glued on, the spool is hydrotested and after successful test the flange is cut resulting in a plain end again.
- **Next important one is that the last joint is a laminated joint and NOT a flanged joint. This is important and the key factor to success and far less leakages.!! In the field flange connection will always fit when not brute force will be used. The same for glued connections between two spools, you can not really handle that accurately.**
- Give the bonders equipment for supporting during spoolbuilding or for alignment is recommended.
- A special place for assembling spools in the field would be nice, to this a separate document about spoolbuilding in Baku (this was a OIL-COMPANY project) is attached addendum 2 “Work shop lay-out”.

Steel table 100% level

11.Work shop lay-out.

Other systems than pipe line installations are normally pre-fabricated. To ensure a good quality of the spools and sufficient out-put, the work shop equipment and lay-out is an important factor. It is recommended to invest time and money to build a good shop. This will be paid back by the higher quality of the pools and quantity of the work.

Space:

GRE fabrication must not be whisked away in a forgotten corner of a steel pipe shop. It is recommended to separate steel pipe work or other activities from GRE fabrication.

Sufficient and clean space is essential for good quality and out-put. The ideal shop has following separate area's:

1. Storage area for pipe and fittings(indoor if possible)
2. Conditioned storage for adhesive, keys, O-rings, chemicals, tooling etc
3. Cutting and shaving area
4. Spoolbuilding area
5. Hydrotesting area
6. Spool lay-down area
7. Office, sanitary facilities, coffee/cantine area

Storage area:

Storage has to be done as per - recommendations. Indoor storing is recommended as materials are dry and clean when needed.

Conditioned storage:

Materials such as adhesive, chemicals (resin and hardner for laminated joints), O-rings, keys, tools etc. have to be stored in a conditioned area. Depending on the environment it can be heated or cooled. Controlling these storages is important to guarantee the quality of the stored goods.

Cutting and shaving area:
Cutting and shaving are activities that do create dust and noise. To make cleaning easier and keep the noise levels in the shop as low as possible, it is recommended to create a separate area for these activities.
For cutting it is recommended to use a bandsaw. Angle grinders can be used but they produce a lot of dust.

M87 shaving tool rigged up

Band saw

Spoolbuilding area:

The spool building area has to be kept as clean as possible. Large tables (approx. 3 x 4 mtr) to work on will speed up the job. Sufficient adjustable supports, extension cables, heating blankets, tools etc. are needed to keep the momentum. Mobile dust extractors are highly recommended to be used on areas in the spoolbuilding area were pipe and fittings are sanded. Lifting equipment like crane or forklift might be needed to safely move spools.

Example of a properly equipped and set up pre-fab shop

Hydrotesting area:

Hydrotesting of spools is an activity that is not without any risk. Therefore the test area has to be a clearly marked and if possible physically from other activities separated area. During hydrotesting it must be clearly marked and unauthorized personnel must be kept out.

Spool lay-down area:
The spool lay-down area must be large enough to allow spools to be laid down without stacking. Storage of spools must be done as per - recommendations. Lay-down are must be physically separated from other activities to avoid accidental damaging of spools due to for example traffic.

Office, sanitary facilities, coffee/canteen area:
An office inside the workshop is required to keep al job related administration.

12.Recommendations to the 1000 h test.

The rather straightforward Shell Dep multiplication factors for the 1000hrs test pressure of pipes and fittings can clearly be communicated with engineering bureaus and end users. The multiplication factors are realistic, not conservative and do have a proven track record over the last 30 years.

- It is recommended to end users to be as close as possible to the Shell DEP multiplication factors with adding the diameter 400 mm for the testing.
- Test at independent institute.
- Weight samples/fittings upfront the 1000 h test, this weight is the minimum weight for supply.
- Determine at strategic places the wall build-up and wall thickness e.g. Neck area bell of a pipe etc.
- Supplier shall demonstrate reproducibility of their products.
- Do this per project or a selection of diameters and fittings per project.

Remark: sometimes it is stated that 90% of the weight of the fitting is also OK. If that is true then test the fitting with the 90% weight and if this one is OK test the one with 90*90 % weight and so on. Somewhere you will find that the $90\%^{n}$ of the weight will not function. This means the tested weight is the minimum weight.

Diameter <= 1200 mm All type of components in project[#]				
Diameter mm	Design pressure	Test temperature	Test pressure	*Qualified range& pressure rating*
250	20 bar	65°C	48.0 bar	[25-250] & 20 bar
400	20 bar	65°C	48.0 bar	[250-400] & 20 bar
600	20 bar	65°C	48.0 bar	[400-600] &20 bar
800	20 bar	65°C	48.0 bar	[600-800] & 20 bar
1200	20 bar	65°C	48.0 bar	[800-1200] & 20 bar

Table: Example recommended tests required acc. author and diameter ranges, required life time20 years acc. Shell DEP multiplication factor = 2,4.

[#] unless otherwise agreed and specified between principal and supplier

Multiplication factors static			
Design Temperature	**<=65 C**	**>65 C**	**Default LCL**
Required design life	X	Y	Z
20 years	2.4	2.6	**Default LCL**
20+n*10 years	$(1.03)^n$*2.4	$(1.03)^n$*2.6	**Default LCL/{**$(1.03)^n$}
60 years	**$(1.03)^4$*2.4 = 2.70**	**$(1.03)^4$*2.6 =2.93**	

Table 20: multiplication factors.

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