FRP/RTRP/GRP-Piping system for all Industrial Applications with in Middle East from 30 years
Sadath A Khan
Engineering Manager
GRP/PE Division-Amiantit Dammam
A Member of Standards Committee
AWWA C-950 and M45-for GRP Pipes
AWWA-D-120 for GRP Tanks
## Presentation Topic

**AMIANIT PIPE SYSTEMS**

- Introduction
- Characteristics of Middle East Region
- Reported Failures of Various Materials
- Optimal Choice of Materials
- Literature Survey Regarding FRP Usage
- FRP or GRP or RPMP or RTRP
- Initiative By Amiantit to Supply FRP in 1977
- 30 Years Journey of GRP
- 30 Years of Supplies to KSA and GCC-ME
- Conclusions and Recommendations
Middle East

- Arid (Dry) Region
- Little or No Rain
- Lack of Fresh Water Resources
- Surrounded by Red Sea,
- Arabian Gulf
Typical Characteristics are

- Varying Geomorphic Conditions
- Changing Climates
- Oscillating Water Tables
- High Salted “Sabkha” Soils
- Fluctuating Humidity's
- Low Electrical Resistivity of Soils
- Fast Track Construction
In Middle East

Sea Water is Desalinated for
Domestic Requirements
Construction Requirements
Industrial Demands etc.

Desalination / Power / Chemical / Oil and Gas Plants are Being Built
along the Coasts of Red Sea and Arabian Gulf.
Factors Affecting Traditional Materials

Seawater of Arabian Gulf and Red Sea

TDS ranges from 40,000 to 65,000 ppm

It contains Dissolved Gases

Decaying Organics, In-Organic and Other aggressive elements

Acting alone or simultaneously produces various forms of Degradation
Factors Affecting Traditional Materials...

Chemical Factors
- Oxygen, H2S, Chlorine
- Solubility, pH, Carbonate Solubility

Physical Factors
- *Velocity*: Air Bubbles, Suspended Solids, Silt
- Temperature and Pressure
Factors Affecting Traditional Materials…

AMIANITIT PIPE SYSTEMS

Biological Factors

Bio Fouling:
Hard Shell, Semi Mobile and Mobile Types

Plant Life and Animal Life:
Oxygen Generation, Carbon Consumption
Common Degradation Process

Piping and other Equipments

- General Corrosion Attack of Material
- Impingement Attack
- Erosion By Suspended Solids
- Crevice Corrosions
- Stress Corrosions Cracking (SCC)
- HAZ(Weld and Heat Affected Zones)
Resulting
Resulting .....
Resulting …….
Resulting ...........

AMIANIT PIPE SYSTEMS
Selection of Materials….

AMIANIT PIPE SYSTEMS

Cost
Plant Life Desired
Feed Characteristics
Material Compatibility
Maintenance Capabilities
Ease of Availability
Overall Life Cycle Capital Cost Constraints
Design and Operating Conditions
Material of Choice for All Applications

Fiberglass Reinforced Plastics
FRP / GRP / GFRP
RTRP / RPMP
FRP-Pipe Wall Construction

AMIANIT PIPE SYSTEMS
FRP-Pipe Wall Construction
Nomenclature
Fiber Reinforced Plastics (FRP)

FRP  Fiberglass Reinforced Plastic (or Polyester)
     or Fiber Reinforced Plastic (or Polyester)
     (European Standards)

GRP  Glassfibre Reinforce Plastic (or Polyester)
     (BS Standards)

RTRP Reinforced Thermosetting Resin Pipe

RPMP Reinforced Plastic (or Polymer) Mortar Pipe
     (American Standards)

FRE  Fiberglass Reinforced Epoxy

GRE  Glassfibre Reinforced Epoxy
Classification
Classification based on Engineering Materials

AMIANITITE PIPE SYSTEMS

Engineering Materials

Metals
  - Basic
  - Alloys

Non Metals
  - Polymers
  - Ceramics
  - Glasses
  - Others
Classification based on Engineering Materials

**Polymers**
- Thermoplastics
  - LDPE
  - HDPE
  - PVC
  - PP
- Thermosets
  - Polyesters
    - Epoxies
    - Alkyds
    - Phenolics
- Elastomers
  - EPDM
  - Neoprene
  - Acrylates
  - Silicones
  - Nitrile
  - F-carbons
FRP-Pipe Wall Construction-Chemistry

Thermoset

Egg

Thermoplastic

Candle
How / Where FRP can be Used?
## Usage of FRP based on Resins

<table>
<thead>
<tr>
<th>Properties</th>
<th>FRP Polyester Piping</th>
<th>GRE Epoxy Piping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>Polyester / Vinyester</td>
<td>Epoxy</td>
</tr>
<tr>
<td>Temperature</td>
<td>Up to 65 °C / 90 °C</td>
<td>Up to 150 °C</td>
</tr>
<tr>
<td>Pressure</td>
<td>Gravity to 40 Bar G / Full Vacuum</td>
<td>Gravity to 200 Bar G / Full Vacuum</td>
</tr>
<tr>
<td>Can Handle</td>
<td>All-Moderate Corrosive Fluids</td>
<td>All-High Corrosive Fluids</td>
</tr>
</tbody>
</table>
Applications
FRP can be used for all types of fluids

AMIANIT PIPE SYSTEMS

- Water Distribution Systems
- Industrial Waste Apps.
- Rehabilitation Applications
- Water Transmission Lines
- Pressure / Forced Mains Sewers
- Water Distribution Systems
- Storm Water Drainage
- Water & Sewage Treatment Plants
- Above Ground Piping
- Suitable usage for more than 400 Chemicals
- Chemical Plants
- Sea Water Intake & Outfall Piping
- Irrigation
- Drinking / Potable Water
- Desalination Plants
- Sub-Aqueous Piping
- Fire Fighting Networks
- Distillate Water Piping
- Hydro-electric Plants
- Slurry Transportation Piping
- Special Applications & Many Other Apps.
- Re-lining, Slip-Lining Applications
- Pipe Jacking & Tunneling Apps.
- Sewage Drainage
Peep in to FRP
Stress Strains- Strength
FRP-Pipe Wall Enlarged Cross Section

- Fibres
- Sand Filler
- Resin

100 microns
FRP-Pipe Stress- Strain

Isotropic materials:
• mechanical properties the same in all directions
• strength and stiffness not dependent on direction
• ex. thermoplastics, metals
  steel:  \( E = 210000 \text{ MPa} \)

Orthotropic materials (GRP):
• mechanical properties direction dependent,
• strength and stiffness dependent on direction
• ex. reinforced concrete, fibre reinforced polyester
  polyester: \( E = 3000 – 4000 \text{ MPa} \)
  continuous glass: \( E = 72000 – 76000 \text{ MPa} \)
FRP-Pipe Stress- Strain

Flowtite vs Steel
Stress-Strain Curves

High pressure pipe - hoop tensile

mild steel
FRP-Pipe Stress- Strain

- High pressure pipe - hoop tensile
- Low pressure pipe - hoop tensile
- Above-ground - axial tensile
- Standard pipe - axial tensile

Stress, MPa

Strain, %
A 10 Bar G – FRP pipe was allowed to BURST and guess expected failure pressure
Comparisons to Various Materials
Pipe Wall-Specific Gravity

- FRP: 1.8
- AL: 2
- STEEL: 8
- CONCRETE: 2.5
- PVC: 1.5
- PE: ~0.96
Coefficient Of Thermal Expansion

AMIANITT PIPE SYSTEMS

10^{-6} \text{ in/in/ } ^\circ \text{ F}

- FRP: ~15
- AL: 15
- STEEL: 8
- CONCRETE: 8
- PVC: 30
- PE: 12
Thermal Conductivity

AMIANIT PIPE SYSTEMS

BTU - in / hr - ft² - ° F

FRP: 1.5
AL: 1500
STEEL: 115
CONCRETE: 7.5
PV C: 1.1
PE: 2.4
ASTM E84 Flame Spread for FRP

AMIANIT PIPE SYSTEMS

Asbestos/Cement
Halogenated-FRP
Halogenated/ w/Antimony-FRP
Red Oak
Plywood
Non-Halogenated

0 25 75 100 200 300 400

Consult data sheets for specific information.
Surge and Water Hammer - Surge wave celerity

AMIANIT PIPE SYSTEMS

Wave Celerity (m/s)

- CONC
- DI
- CS
- FRP
- PVC
- PE50
Usage of FRP World Wide- Literature Survey
Usage of FRP World Wide- Literature Survey

- In 1970, φ 1350 mm - Canada
- In 1974, φ 1200 mm - Peru
- In 1975, Office of Saline Water - USA, recommends GRP in Desal Plants
- In 1980, Reynolds recommends GRP in Distribution and Other Systems
- In 1981, Ainsworth recommends GRP for Different Applications
- More Reported Literature … available
FRP-Life Cycle Costs
Saving Time and Money-Life Cycle Costs

AMIANIT PIPE SYSTEMS

Material
Installation
Maintenance

Steel  Plastics
# Saving Time and Money—a Real Example

## AMIANTIT PIPE SYSTEMS

<table>
<thead>
<tr>
<th></th>
<th>1400 Dia. Steel (C)</th>
<th>1400 Dia. GRP</th>
<th>1300 Dia. GRP</th>
<th>1200 Dia. GRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, mtr</td>
<td>105</td>
<td>60</td>
<td>82</td>
<td>115</td>
</tr>
<tr>
<td>Pump, KW</td>
<td>3156</td>
<td>1803</td>
<td>2464</td>
<td>3456</td>
</tr>
<tr>
<td>Pipe Cost, $ Mil</td>
<td>13.75</td>
<td>15.68</td>
<td>13.75</td>
<td>12.10</td>
</tr>
<tr>
<td>Pump Cost, $ Mil</td>
<td>0.27</td>
<td>0.15</td>
<td>0.21</td>
<td>0.29</td>
</tr>
<tr>
<td>Instal Cost, $ Mil</td>
<td>14.02</td>
<td>15.83</td>
<td>13.96</td>
<td>12.39</td>
</tr>
<tr>
<td>Comparison</td>
<td>100%</td>
<td>113%</td>
<td>100%</td>
<td>88%</td>
</tr>
<tr>
<td>Power cost, $ Mil</td>
<td>2.03</td>
<td>1.16</td>
<td>1.59</td>
<td>2.22</td>
</tr>
<tr>
<td>Annuity, Af=0.106 @ 10%, for 30 yrs</td>
<td>19.17</td>
<td>10.94</td>
<td>14.95</td>
<td>20.97</td>
</tr>
<tr>
<td>Project Cost, $ Mil</td>
<td>33.19</td>
<td>26.77</td>
<td>28.91</td>
<td>33.36</td>
</tr>
<tr>
<td>Comparison</td>
<td>100%</td>
<td>81%</td>
<td>87%</td>
<td>101%</td>
</tr>
</tbody>
</table>
Amiantit Initiative- GRP Plant in 1977
In Dammam – Saudi Arabia
Amiantit Initiative-1977 Start of GRP Plant

- Saudi Arabian Amiantit Company – SAAC-Started GRP Plant in 1977
- JV with Owens Corning (OC)/Flowtite/SAAC
- SAAC-overtake OC in 2000
- Globalization Commences in 2000
- One of the worlds biggest capacities
- More than 15 Machines
- Continuous production-365/7/24
30 Years of Journey of GRP

AMIANTIT PIPE SYSTEMS

- AFIL-Dammam-1977
- AFIL-Jeddah-2000
- FPCL: Fiberglass Pipe Company Limited-2001
- DPFCL: Dubai Pipe Factory Company-2002
- AQAP: Amiantit Qatar Pipes Company-2008
- ABHL: Amiantit Bahrain Holding Limited-2010
30 Years of Journey of GRP...

AMiAntiT PIPE SYSTEMS

- 8 Machines at AFIL - Dammam
- 6 Machines at AFIL-Jeddah
- 2 machines at FPCL- Dammam
- 2500 Machine at DPFC- Dubai
- 4000 mm machine at Qatar-2008

4000 mm machine at Bahrain-2010 is coming up
# Product Range

## AMIANTIT PIPE SYSTEMS

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diameter</strong></td>
<td>80 mm to 4000 mm</td>
</tr>
<tr>
<td><strong>Pressure</strong></td>
<td>Gravity to 40 Bars (464 psi)</td>
</tr>
<tr>
<td><strong>Stiffness</strong></td>
<td>1250, 2500, 5000, 10,000</td>
</tr>
<tr>
<td></td>
<td>12,500 Pa</td>
</tr>
<tr>
<td><strong>Joint System</strong></td>
<td>Couplings, Butt-strap, Flngs</td>
</tr>
<tr>
<td><strong>Installation</strong></td>
<td>Underground, Aboveground</td>
</tr>
<tr>
<td></td>
<td>Under Sea Applications</td>
</tr>
<tr>
<td><strong>Resin</strong></td>
<td>Polyester, Vinylester &amp; Epoxy</td>
</tr>
<tr>
<td><strong>Tanks</strong></td>
<td>U/G Up to 48,000 USG</td>
</tr>
<tr>
<td></td>
<td>A/G H Up to 35,000 USG</td>
</tr>
<tr>
<td></td>
<td>A/G V Up to 30,000 USG</td>
</tr>
<tr>
<td><strong>Structural MH &amp; Liner</strong></td>
<td>1000 &amp; 1200 mm Dia</td>
</tr>
<tr>
<td>Diameters</td>
<td>80 mm</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>Pressure</td>
<td>Gravity</td>
</tr>
<tr>
<td>Application</td>
<td>UG</td>
</tr>
<tr>
<td></td>
<td>Under Sea</td>
</tr>
</tbody>
</table>
# FRP-Pipe Stiffness - Range

<table>
<thead>
<tr>
<th>AMIANTIT PIPE SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Load</strong> = $P$</td>
</tr>
<tr>
<td>2 x $P$</td>
</tr>
<tr>
<td>4 x $P$</td>
</tr>
</tbody>
</table>

- **2500 Pa**
- **5000 Pa**
- **10000 Pa**
30 Years Supplies and Applications
Under Ground
Above Ground
Under-Sea / Off-Shore
On Ground
Slip Lining
ALL Types of Fittings Were Fabricated

Elbows, Tees, Reducers, Flanges, Blind
All Types of Fittings are Possible
Under Ground
Above Ground
Under-Sea / Off-Shore
On Ground
Slip Lining
Under-Sea Continued....

Around 50 Projects were already under operation
Diameters Up to 3700 mm
Supported in Design/ Installation in Various Projects
Sub-Aqueous Installation

Rock (Rip Rap) Approximate
Ø 300mm - Ø 400mm

Mixture of native soil
(Max size : 100mm)

Bed and backfill is
well graded crushed
aggregates (Max size :
25mm)

Filter Fabric to be used
if erosion is expected

ND

Sea Bed

300

1000

1.5 x ND

1000

Amiantit
FIREGLASS
SECTION THRU PIPE

ISOMETRIC VIEW OF PRECAST CONCRETE BLOCK
FOR CENTRAL 5m OF MAT

NOTE: ALL DIMENSIONS ARE IN METERS.
## Performance of FRP in P and D Plants

1. Under Ground
2. Above Ground
3. Under-Sea / Off-Shore
4. On Ground
5. Slip Lining
On Ground Applications

- For Sewage and Water Line With Flexible Couplings and Special Supports
- Useful for Rugged Terrain
- Can be Used for Slopes
- Similar Lines Under Operation
Figure 4.1
*Flowtite* pipes. Typical support arrangement

Figure 4.2
Cradle design
Typical Oldest Case Histories >25 Years
Results of GRP pipe Installed in 1980

AMIANIT PIPE SYSTEMS

Traceability and Pipe Identification

- Pipe Nominal Diameter: 1800 mm
- Pipe Identification number: 2B-1910-X
- Pipe production date: 09th July 1980
- Nominal Pipe wall thickness: 22.71 mm
- Pipe nominal Pressure rating: H-010 K Pa
- Pipe Nominal Stiffness: 1388 Pa STIS
- Pipe Actual Stiffness: 1432 Pa STIS

Hoop Tensile Strength: 45 MPa
Axial Tensile Strength: 25 MPa
Results of GRP pipe Installed in 1980...
To Conclude and Summarize........
### Summary of 30 Years GRP Supplies

**Diameters**
- 80 mm
- 4000 mm

**Pressure**
- Gravity
- 40 Bars G

**Application**
- UG
- AG
- Under Sea
- Relining
## Summary of 30 Years GRP Supplies...

<table>
<thead>
<tr>
<th>Type of Production</th>
<th>Quantity</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aboveground Horizontal Tanks</td>
<td>1,648</td>
<td>pcs</td>
</tr>
<tr>
<td>Aboveground Vertical tanks</td>
<td>1,243</td>
<td>pcs</td>
</tr>
<tr>
<td>Underground storage tanks</td>
<td>5,111</td>
<td>pcs</td>
</tr>
<tr>
<td>Large diameters for Sewer</td>
<td>4,321,795</td>
<td>Meters</td>
</tr>
<tr>
<td>Large diameters for water</td>
<td>1,983,848</td>
<td>Meters</td>
</tr>
<tr>
<td>Small Diameters Pipes for Sewer</td>
<td>3,814,540</td>
<td>Meters</td>
</tr>
<tr>
<td>Small Diameters Pipes for Water</td>
<td>504,350</td>
<td>Meters</td>
</tr>
<tr>
<td>Aboveground Pipes</td>
<td>285,420</td>
<td>Meters</td>
</tr>
<tr>
<td>Perforated Pipes</td>
<td>101,176</td>
<td>Meters</td>
</tr>
</tbody>
</table>
Summary of 30 Years GRP Supplies… …

AMIANIT PIPE SYSTEMS

Below Ground

24 meters

Above/ Industrial Piping

Pipe Lining/Rehabilitation

A Total of 11,559 Km - GRP supplied
Finally Some Interesting Applications……
Conclusions and Recommendations

• GRP Pipes are suitable for All Applications better than that of Traditional Materials
• No Maintenance, **INSTALL it** FORGET it
• Not in Theory but Exists over **30** Years
• Commercially Viable
• Greater Flexibilities
• Need to Adopt Now in All Applications
YOU CAN CONTACT me
sadathcn@yahoo.com
sadathcn@gmail.com
Middle East Region
Middle East Region