

EVALUATION OF CAMISEA PROJECT PIPING FAILURES AND LONG-TERM SOLUTIONS

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Note: The decisión to incorporate TGP/Techint Project documents as attachments to this report was exclusively the decisión of Mr. Powers of E-Tech International.

TABLE OF CONTENTS

	<u>Page</u>
1.0 Executive Summary	1
2.0 Introduction	3
3.0 Description of the Natural Gas and Natural Gas Liquids Pipelines	3
4.0 Peruvian Pipeline Construction Regulations	5
5.0 Methodolgy Used to Verify Piping and Certify Welders and Inspectors	6
6.0 Observations of the IDB Inspectors Regarding the Condition of the Right-Of-Way During the Construction Phase.....	7
7.0 Quality of Piping Used in the Camisea Project	7
7.1 Welding Problems	8
7.2 Problems with Weld Inspection in the Field	9
8.0 Quality of Hydrostatic Testing in the Field	10
9.0 Pipe Failures in the NGL Pipeline.....	10
9.1 Analysis of the First Failure	10
9.2 Analysis of the Other Three Failures	14
9.3 Possible Actions that Could be Taken to Foresee Future Failures.....	15
10.0 Location of the Most Problematic Pipeline Sections	15
11.0 Alteration of the Original Route Without Authorization	16
12.0 Erosion Control Policy of TGP/Techint	16
13.0 Erosion Control Policy of the Ministry of Energy and Mines.....	17
14.0 Erosion Control Reality During the Construction Phase of the Project.....	21
15.0 Conclusions	22

Figures	<u>Page</u>
1. Camisea Project – Location of Bases and Installations	4
2. Outline of the Natural Gas Transport System	4
3. Outline of the Natural Gas Liquids Transport System	5
4. Types of Corrosion in Metals and Alloys.....	8
5. Location of the December 22, 2004 Pipeline Break.....	11
6. Quantity of Natural Gas Liquids Spilled on December 22, 2004	12
7. Containment of Liquids After Spill on December 22, 2004.....	12
8. Site Remediation After Spill on December 22, 2004.....	13
9. Photo of December 22, 2004 Pipe Break	14
10. Smart Pig to Measure Pipe Wall Thickness.....	16
11. Factors that Influence the Formation of Unstable Soil Zones	18
12. Techniques for Stabilizing Unstable Slopes	19
13. Sketch of Rigid Containment Walls	19
14. Sketch of Flexible Containment Walls	20
15. Sketch of Reinforced Soil Structures.....	20

Attachments

1. MEM - *Environmental Management Guide for Pipelines*
2. Specification used by TGP/Techint for construction of NGL pipeline
3. Specification used by TGP/Techint for welders and weld inspectors
4. URS report to IDB - March 2003 - observed deficiencies
5. Specification used by TGP/Techint for fabrication of piping
6. Tenaris announces production of 68,000 tons of piping for Camisea
7. Specification used by TGP/Techint for taking and interpreting radiographs
8. Hydrostatic test report signed by inspectors without certification
9. Reports of OSINERG and DIGESA on the first pipe break on December 22, 2004
10. Topographic map of the area of the first pipe break
11. Report of OSINERG on the third spill on August 29, 2005
12. Topographic maps of the areas of the subsequent three pipe breaks
13. Maps of problematic pipeline segments
14. Photos of soil movement caused by trenching and route change in highlands
15. Specification used by TGP/Techint for erosion control

1.0 EXECUTIVE SUMMARY

This report examines the causes of four Camisea natural gas liquids pipeline ruptures during the first fifteen months of operation, the characteristics of the ruptures, and where future ruptures are likely to occur. The author of this assessment is a certified pipeline welding inspector who inspected sections of the Camisea pipelines during the pipeline construction phase. The fundamental conclusion of this report is that the principal concern of the consortium building the pipelines was to complete the project within the timeline established by the Peruvian government. Each day of delay beyond the target completion date would have resulted in fines that could have risen to as much as \$90 million. The consequence of the rush to complete the project was a series of omissions and irregularities during construction that violated standard pipeline construction practices and Peruvian regulations.

The four ruptures of the natural gas liquids pipeline that have occurred to date took place at km. 9, km. 51, km. 200, and km. 220. The ruptures occurred for a variety of reasons, including inadequate welds, inadequate inspection of welds, corrosion of the piping, and soil movement. The pipeline sections with a high potential for future ruptures are km. 8 to km. 10; km. 25 to km. 52; km. 70 to km. 172; km. 200 to km. 225; km. 355 to km. 370; and km. 436 to km. 450. These sections are located in very difficult terrain, with pronounced curves and slopes. The approach used under time pressure was to employ special piping joints to pass through these difficult sections of the route, with the attendant risk of weld failures, instead of choosing a less physically challenging pathway that might have required more time. The principal problems with the field welding were: 1) welders without proper certifications, 2) welds made by welders without experience given promotions in the field from welder's helpers to welder and 3) unacceptable stresses imposed to maintain the pipe ends in position to permit welding. The loading caused by soil movement due to inadequate soil stabilization and revegetation work along the pipeline route. was not anticipated in the design of the pipelines and has produced fatigue cracks in the piping.

It is the opinion of the author of this report that at least half of the pipe used in the Camisea pipelines is leftover pipe from other pipeline projects. This piping was stored outside in Ecuador and Brasil for extended periods of time before being shipped to Peru. These pipes arrived in Peru with excessive corrosion. The corrosion was sufficient in some of these pipes that the pipe wall thickness was reduced below acceptable thresholds defined in the applicable pipeline construction codes ASME B31.4 (construction and operation of pipelines transporting liquids) and ASME B31.8 (construction and operation of gas pipelines). The pipe arrived in Peru with the tapered pipe ends deformed due to inadequate storage and transportation procedures. The poor condition of the pipe required that field repairs be conducted although neither adequate equipment nor personnel were available for this task. The piping was then welded by welders without proper qualifications and supervised by personnel without proper qualifications. The soil stabilization work was inadequate in certain sections of the pipeline. This resulted in soil movement that has placed additional stress on bad welds in piping that is weaker than required by the applicable pipeline construction standard.

Peruvian law requires a hydrostatic test at 150% of normal operating pressure in order to verify pipeline integrity before commercial operation begins. Although the hydrostatic testing was properly conducted in certain cases, in other instances there were serious deficiencies and irregularities. For example, these tests were not carried out by trained or certified personnel. It is also required that the testing instrumentation calibrations must be certified by an independent laboratory or certified personnel. None of these requirements were met. Instrument calibration should have been conducted in the presence of Peruvian government representatives and not exclusively by Techint and TGP personnel as occurred in the field during the construction phase.

A complete examination of pipeline construction and radiographic analysis of pipeline welds is required to properly assess pipeline integrity. This is necessary to avoid more ruptures that could compromise public safety, cause additional environmental damage, and place at risk the natural gas supply for Lima. It is essential that certified specialists, observed by independent inspectors, radiograph 100 percent of the pipeline welds. Other pipeline integrity tests and procedures, such as hydrostatic testing, intelligent pigs, and remote sensing leak detection measures, should be employed as required to thoroughly document the current condition of the pipelines. Independent inspectors must also assess the adequacy of soil

stabilization and revegetation along the length of the pipeline, recommend detailed remedial action measures to assure soil stability, and monitor the progress of remedial action measures until the damaged areas are fully stabilized and restored.

2.0 INTRODUCTION

This report examines the causes of the four Camisea natural gas liquids pipeline ruptures that occurred during the first fifteen months of pipeline operation, the characteristics of these ruptures, and where future ruptures are likely to occur.

Camisea is the largest energy project in the history of Peru. The project involves the extraction of natural gas and natural gas liquids from an area in the Peruvian Amazon along the Urubamba River known as Block 88 and Block 56. The project's total cost is \$1.6 billion dollars, and includes construction, operation, gas processing, and the construction of two gas pipelines. The pipelines traverse the Andes prior to reaching the coast for distribution.

Block 88 contains 11 trillion cubic feet of probable gas reserves and 600 million barrels of natural gas liquids. Block 56 contains 3 trillion cubic feet of probable gas reserves and 220 million barrels of natural gas liquids according to PeruPetro. The Camisea Project started production in August of 2004 from Block 88. The natural gas pipeline and the natural gas liquids (NGL) pipeline are operating at initial capacities of 285 million cubic feet per day and 50,000 barrels per day, respectively.

Shell was going to construct the Camisea Project at the end of the 1990's but could not reach an agreement with the Government of Peru (GoP) on royalties. Soon after the GoP initiated another round of bidding for the Camisea reserves. The consortium offering the most royalties to GoP would be awarded the project. Simultaneously, the GoP set a pipeline start date of August 1, 2004 and established a system of progressively more punitive fines for failure to meet completion deadlines. The TGP consortium consisting of Techint (Argentina), PlusPetrol (Argentina), and Hunt Oil (USA), won the bid to construct the pipelines in October 2000. These pipelines began operation on August 8, 2004. The Camisea natural gas liquids pipeline suffered four ruptures during the first fifteen months of operation (August 2004 – November 2005).

3.0 CAMISEA NATURAL GAS AND NATURAL GAS LIQUIDS PIPELINES

The Camisea pipeline system consists of a 732 km. gas pipeline and a 650 km. natural gas liquids pipeline (Figure 1). The Camisea pipelines begin at the Malvinas gas plant located in the Department of Cuzco, in the Rio Urubamba river basin. The pipelines traverse the Peruvian Amazon rain forest and cross the Andes mountains at an elevation of 4,800 meters above sea level. The natural gas pipeline terminates in the city of Lurin, located 30 km south of Lima. A pressure control station was installed on the natural gas pipeline at km 472, a downslope area, in order to control receipt point pressure at Lurin.

The NGL pipeline terminates at the NGL fractionation plant located south of Pisco, near the Bahía de Paracas. The NGL pipeline includes four (4) pump stations designed to maintain pipeline pressure move the NGL to the final receipt point. Three additional pressure reducing stations were installed along the downslope leading away from the highest Andes peaks to the fractionation plant (the final pressure reducing station is located at Terminal Lobería Beach).

Figure 1. Camisea Project – Location of Bases and Installations

(source: Compañía Operadora de Gas del Amazonas, *Descripción del Sistema de Transporte por Ductos*, no date)

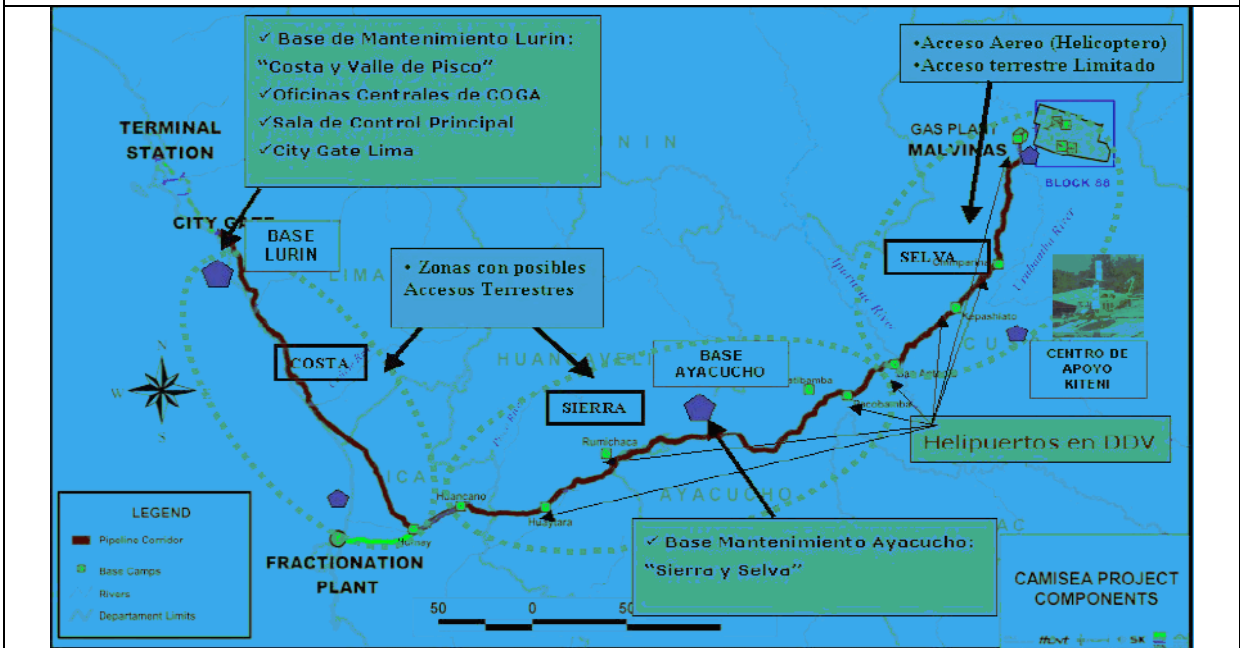


Figure 2. Outline of the Natural Gas Transport System

(source: Compañía Operadora de Gas del Amazonas, *Descripción del Sistema de Transporte por Ductos*, no date)

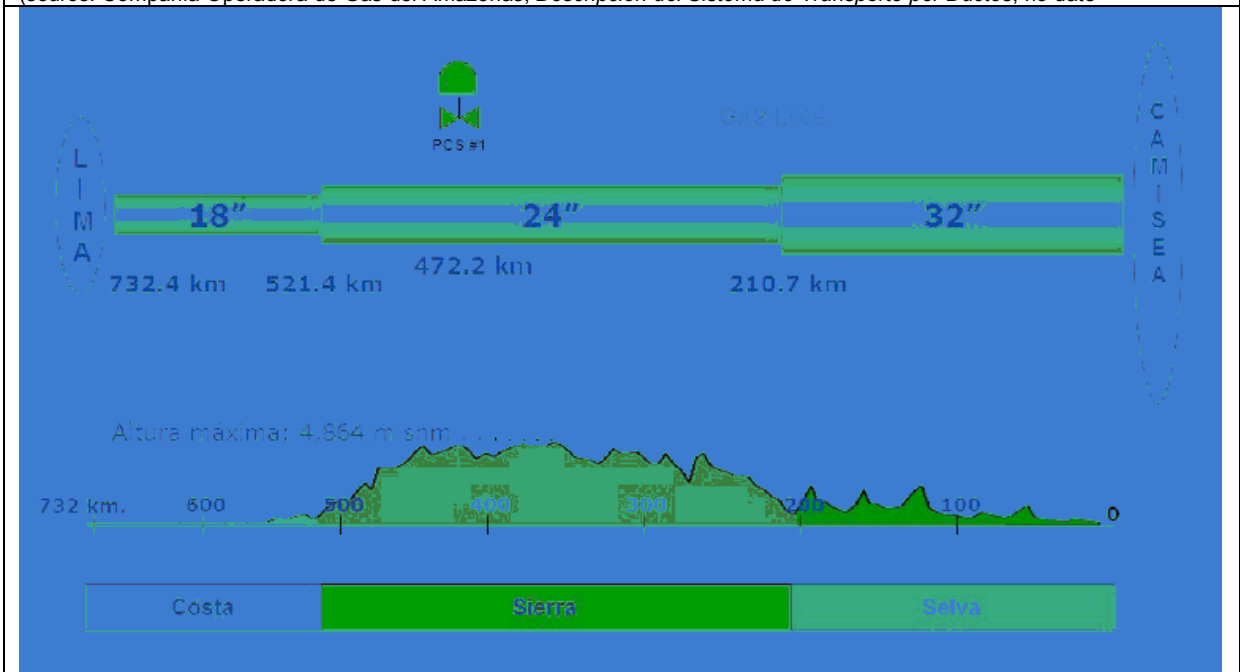
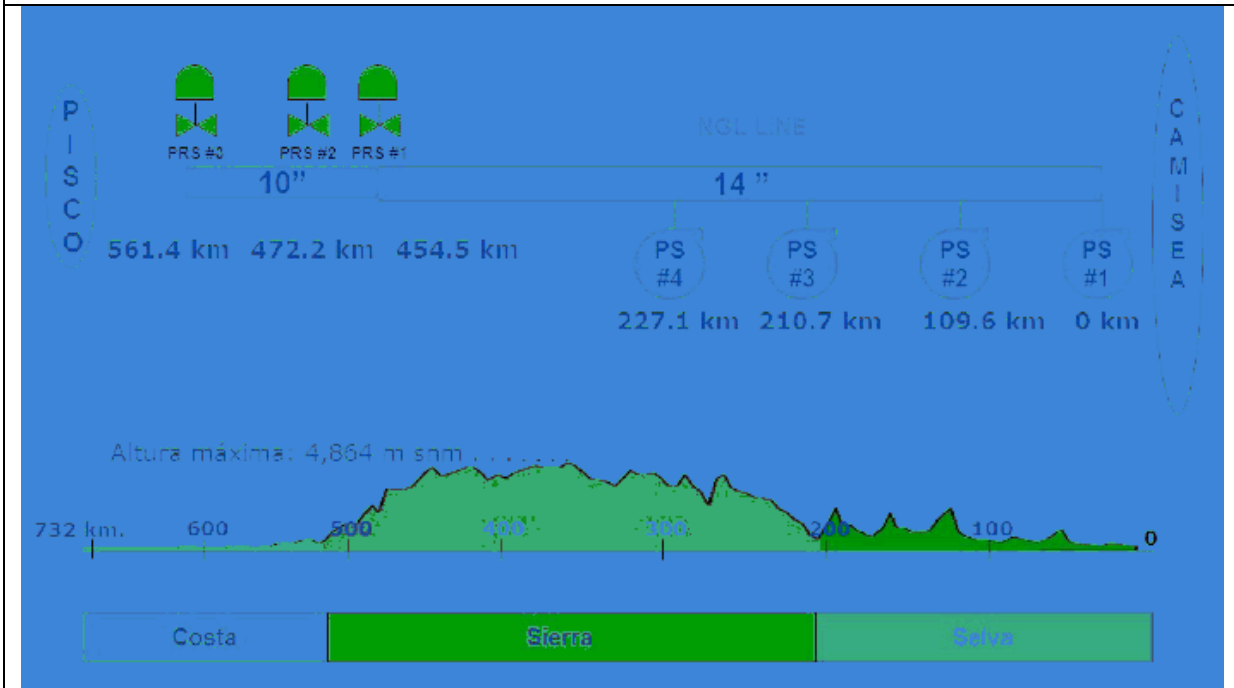


Figure 3. Outline of the Natural Gas Liquids Transport System

(source: Compañía Operadora de Gas del Amazonas, *Descripción del Sistema de Transporte por Ductos*, no date)



4.0 PERUVIAN PIPELINE CONSTRUCTION REGULATIONS

The August 20, 1993 Hydrocarbon Law - No. 26221 - is the fundamental legislation that regulates oil and gas development in Peru. The Environmental Protection Regulation for Hydrocarbon Activities (November 12, 1993 - Supreme Decree N° 046-93) is the first regulation that specifically defined the environmental requirements for oil and gas projects and the construction of pipelines.

Article 46 includes the following specific regulations for hydrocarbon transport and storage:

- In river crossings, pipelines must be buried under the river bed or must be installed above water;
- Check valves must be installed in order to stop or minimize spills in the event of a pipeline rupture;
- All tubing joined with welds must be tested using non-destructive methods (radiography/x-ray) before the pipeline is put into operation;
- All tubing must be subjected to a hydrostatic test with a minimum test pressure 150 percent of normal operating pressure;
- Pipelines must include devices for the measurement and control of flow that allow for the continuous control of pumped and received volume.

In addition to the Supreme Decree N° 046-93-EM, the Ministry of Energy and Mines defined best environmental practices during the construction and operation of oil and gas pipelines in the *“Environmental Guide for Management of Oil Pipelines”* published in 1994. The guidelines established in this document reflect oil industry practices utilized in many

countries. The relevant portions of this guide that relate to Camisea Project are provided in Annex 1.

5.0 METHODOLOGY USED TO VERIFY PIPING AND CERTIFY WELDERS AND INSPECTORS

American Society of Mechanical Engineers – ASME B31.8, “Gas Transmission and Distribution Piping Systems” establishes the necessary requirements for the reliable design and construction of pressurized piping carrying natural gas or natural gas liquids. TGP/Techint adopted ASME B31.8 as the specification for the construction of the Camisea natural gas pipeline and the NGL pipeline.

ASME B31.8, Capítulo II –Soldadura: Section 823.21 underscores that welding procedures and welder qualification must adhere to API 1104 (API 1104 is discussed in more detail below) or the ASME equivalent. Also the code notes that each weld must be inspected visually in the field and by radiography or other equivalent non-destructive method.

Section 826.1 specifies that quality of the weld must be visually inspected, using a grid pattern, and defective welds must be repaired or removed.

Section 826.2 specifies that the weld quality will be verified through a non-destructive test method.

ASME B31.8, Capítulo IV – Diseño, Instalación y Pruebas: The maximum natural pipeline pressure calculation is based on the “strength of design” of the newly manufactured piping for the specific project. Additionally, this section of the Code specifies strength calculations for the piping used on a project. The Code section also sets strength calculations for piping that has degraded due to exposure and poor transport. The objective is to insure that pipelines are not operated above calculated maximum pressure.

American Petroleum Institute Código API 1104 “Welding of Pipelines and Related Facilities”: API 1104 sets out the testing requirements that each welder and inspector must pass to qualify. Visual and radiographic inspectors that inspect each individual weld must obtain certification prior to working in the field. According to API 1104, the construction company Techint must maintain exam records for each welder and the work records of each weld and radiographic inspector that worked on the project. TGP incorporated the API 1104 standard as its regulation regarding welders and weld inspectors. See Attachment 3.

TGP adopted the API5 specifications for its natural gas and natural gas liquids pipelines. API 5L requires the manufacturer to provide the buyer proof of materials used in pipe manufacture with seven (7) days of manufacture. The incorporation by TGP of the API 5L standard required and implies that all of the pipes used in this project was newly manufactured.

6.0 OBSERVATIONS OF THE IDB INSPECTORS REGARDING THE CONDITION OF THE RIGHT-OF-WAY DURING THE CONSTRUCTION PHASE

URS, an American consulting, firm produced and delivered monthly progress and deficiency reports to the Inter-American Development Bank (IADB) and the Andean Corporation for Development (CAF). These monthly reports are available on the Camisea Project's webpage at <http://www.camisea.com.pe/>. Please go to the "Technical Reports – Transportation" and "Monitoring Reports of Matrix" to find these monthly reports. Although these monthly reports are limited to monitoring the right of way (DDV) and the camps, the observations reflect the atmosphere in the field during the construction phase - an atmosphere of negligence and pressure to move forward without suitably addressing deficiencies or weighing the ramifications of these deficiencies on future pipeline operations. An example appears in Attachment 4, an extract of the report produced by URS for March 2003 that discusses the observed deficiencies.

7.0 QUALITY OF PIPING USED IN THE CAMISEA PROJECT

A fundamental step in the construction of an oil or natural gas pipeline is the use of new and physically sound pipe. The success of a pipeline project over time depends largely on the quality of the pipe and welds. Therefore, the standards that are applied to the pipe and the weld are very demanding. The pipe must meet a standard known as API 5L. This standard defines the metallic composition, forces, resistance, et cetera. In addition, each tube must have a unique identification number (see Attachment 5). The construction company, in this Techint case, must archive the identification number of each tube utilized throughout the pipeline. This archive is called a "paybook" in the industry. It is possible to trace the history of each tube in the pipeline by means of the paybook.

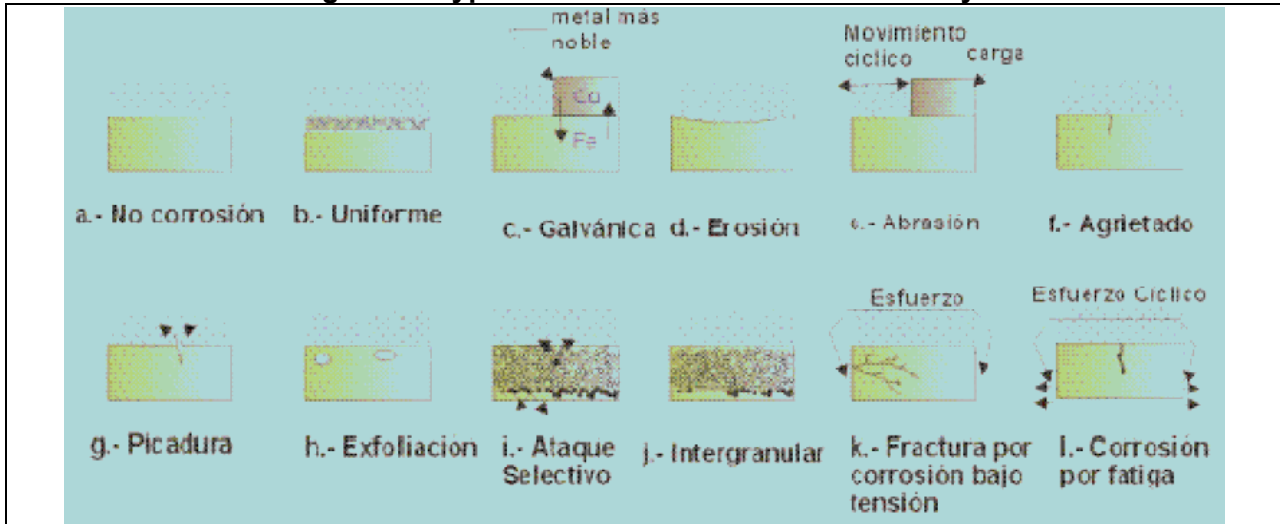
The author of this document estimates that at least half of the pipe used to build the Camisea pipelines is left over from other projects in Ecuador and Brasil. The author was in the field inspecting the construction of the pipelines. The left over pipe was stored outdoors and due to exposure to the elements arrived in Peru with excessive corrosion. Due to corrosion, the wall thickness of the pipe were below acceptable limits required by API 1104 and ASME B31.8. Tenaris was the only fabricator of pipe used on the project. The percentage of left over pipe used can be indirectly corroborated through a press announcement published by Tenaris, the company within the Techint Group that manufactures pipe. Tenaris was the only fabricator of pipe used on the project. Tenaris indicated that it fabricated approximately 68,000 tons of the 200,000 thousand tons of pipe that provided to the Camisea Project. See Attachment 6. In reality, the percentage and history of the pipe used to construct the Camisea pipelines can be verified through an analysis of the paybook maintained for both pipelines by Techint.

The used pipe was delivered to Peru with deformed bevels due to poor transport and storage. The bevels had to be repaired manually. According to standard, a section of pipe must be cut no more than 1 meter beyond its deformity (minimum length issue). Cuts were often made up to 1.5 meters in length due to excessive corrosion. Cuts and repairs of this magnitude in the field make the welding more difficult and the weld quality more difficult to control.

7.1 WELD PROBLEMS

Factory and onsite weld problems are directly related to issues such as pipe fatigue, corrosion, and unexpected fractures that have occurred during the operating phase. See Figure 4.

Figure 4. Types of Corrosion in Metals and Alloys



The problems observed by the author during the construction phase of the Camisea pipeline include:

- Factory welds lacking penetration;
- Uncertified and unqualified welders;
- Welds conducted by inexperienced assistants hastily promoted to welders;
- Bad preparation of pipe bevels due to damage or generalized internal corrosion;
- High frequency of tension and fatigue due to general pipe corrosion;
- Excessive pressure on pipe “tie-ins”, such as special crossings and other “tie-in” unions of pipes in special sites such as gorges or small rivers;
- Changes in dimension, distortion, and excessive tension on the pipes that were welded while held by force during the weld process. This affects the weld and is often the cause of ruptures;
- Weld fatigue is responsible for approximately 90% of the breakdown of welded unions prior to rupture;
- Bad welds - the discontinuity and defects in the welds concentrate pressure on to load fissures caused by fatigue that slowly reaches critical size;
- Landslides and soil movement can cause pipe deformation that with time produces a fissure due to fatigue.

It is essential to underscore that the welding specification used by TGP, API 1104, requires that Techint use only well qualified welders and that the company maintain copies of welder examinations that must take place before the project work begins. These exams serve as proof that each welder working on the Project is at the level necessary to perform with success using the equipment and techniques required by the Project. The welders must pass by examination each procedure that will be used in the project in accordance with API 1104. If not, the welder is limited to only those techniques where the welder’s skill level is satisfactory. In the case of this project, although all of the welders became certified, it is the opinion of the author of this

report that there was not good control over the examination process and a percentage of the welders simply were not have the necessary level of experience for the project.

7.2 PROBLEMAS CON LA INSPECCIÓN DE LA SOLDADURA HECHA EN EL CAMPO

Every pipeline weld requires a examination by radiography in the field to confirm the quality and integrity of the weld. Each weld must have a unique identification number. It is necessary to document the name of the welder that made the weld, the inspector World visually inspected the weld, and the radiologists that photographed and interpreted the image of the weld. The objective of this system of examinations, identification numbers, and documentation of inspection for each field weld is to assure adequate quality control. API 1104 requires that the radiologists must be Level II or Level III professionals, following the certification procedures of the *American Society for Nondestructive Testing, Recommended Practice No. SNT-TC-1A*, or equivalent, to take radiographs of weld. Level II and III signify radiologists highly skilled in the interpretation of radiography for welding. Only Level II or III radiologists in interpretation can interpret the results of radiographic images. Also, the contractor, in this case Techint, must maintain a record of the certification tests of each radiologist.

It is through this documentation, or the lack thereof, that the qualifications of personnel conducting welding, welding inspection, and radiography of the welds in the field can be corroborated. One of the causes of the premature failure of piping has to do with the use of welders, welding inspectors, and radiologists that were not adequately prepared for the work they were doing.

There were radiologists certified to take radiographs working on the Camisea Project. The problem is that these specialists also interpreted the radiographs without the proper training. The only specialist qualified to interpret radiographs is one who has been specifically trained and tested to demonstrate the necessary Level II or Level III knowledge. The only professional in the TGP/Techint team that was certified to interpret radiographs was never in the field to actually perform that task. Radiographs were not interpreted by appropriately certified personnel.

Welding inspectors, those that perform the visual examination of the welds, are certified by the American Welding Society – AWS. AWS certifies three categories of inspectors:

- CWI – Certified Welding Inspector – is the welding inspector;
- CAWIN – Certified Associate Welding Inspector - is an inspector limited to a specific company (not at the level of a CWI);
- Engineer Inspector – is a specialist in welding and ranks about the previous two inspector categories.

Both TGP and Techint employed welding inspectors. TGP's role was to oversee the entire Camisea Project. TGP contracted with Techint to construct the pipelines. Techint was also a shareholder in TGP. Techint used its own personnel to weld and inspect weld during the construction. TGP supervised the work of Techint's personnel also. However, TGP only had a single inspector CWI and no inspectors at the CAWI level or the Engineer Inspector level. Techint did not have any welding inspectors certified by any internationally recognized welding certification organization such as API, AWS, or ASME.

8.0 QUALITY OF HYDROSTATIC TESTING IN THE FIELD

Hydrostatic testing is an essential step in the construction of a pipeline. After welding 10 to 15 kilometers of pipe and before burying the pipeline, both ends of a section of pipeline are sealed and filled with water. Pressure greater than normal operating pressure is applied. The objective is to verify the integrity of the pipeline section before putting it into operation.

It is common practice to retest failed sections with additional hydrostatic tests. It may be necessary to subject the entire pipeline to hydrostatic testing after: 1) reinforcing the slopes throughout the right-of-way to assure the physical stability of each pipeline segment and, 2) testing and repairing bad sections of pipe.

The quality of hydrostatic tests performed by TGP personnel has been variable. There were no independent inspectors verifying the calibrations of the hydrostatic test equipment or the qualifications of test personnel during the pipeline construction phase. The personnel who carried-out the hydrostatic tests did not have any recognized certifications authorizing them to conduct such tests. TGP did not employ personnel qualified to carry out the hydrostatic tests during the construction phase. A hydrostatic test report signed by test personnel without certifications to conduct hydrostatic testing is provided in Attachment 8. These informal test practices are contrary to the standards of ASME and API that TGP/Techint adopted as standard procedures. Industry standards required TGP/Techint personnel to be properly certified and qualified before conducting critical work, not only hydrostatic testing but also welding and weld inspection. The informal practices and lack of independent inspectors cast doubt on the validity and reliability of the tests performed.

9.0 PIPE FAILURES IN THE NGL PIPELINE

9.1 ANALYSIS OF THE FIRST FAILURE

December 22, 2004 rupture. The break took place at km. 8.8 in a 14-inch section of the NGL pipeline. This rupture occurred after only five months of operation. The spill dumped hydrocarbons into the Kemariato Gorge and Rio Urubamba-Malvinas. A sketch of the location of the rupture is shown in Figure 5. The quantity of liquids spilled, 183 cubic meters, is identified in the sketch provided in Figure 6. These two sketches come from the OSINERG report on the incident (Attachment 9). DIGESA also prepared a brief analysis of the incident which is included in Attachment 9 as well. The site of the break is identified on a topographic vicinity map in Attachment 10.

Figure 5. Location of the December 22, 2004 Pipeline Break

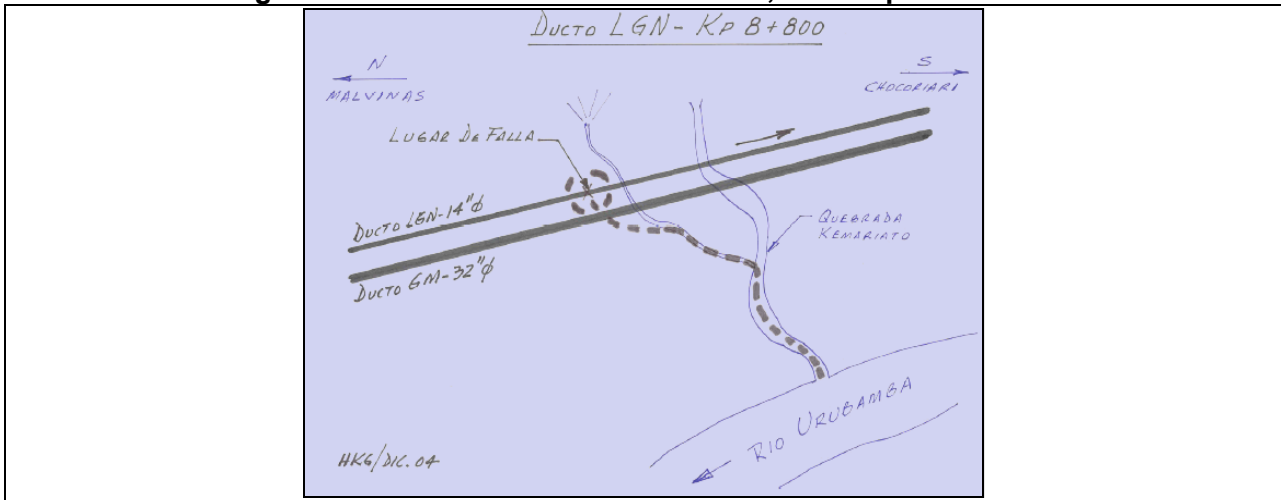
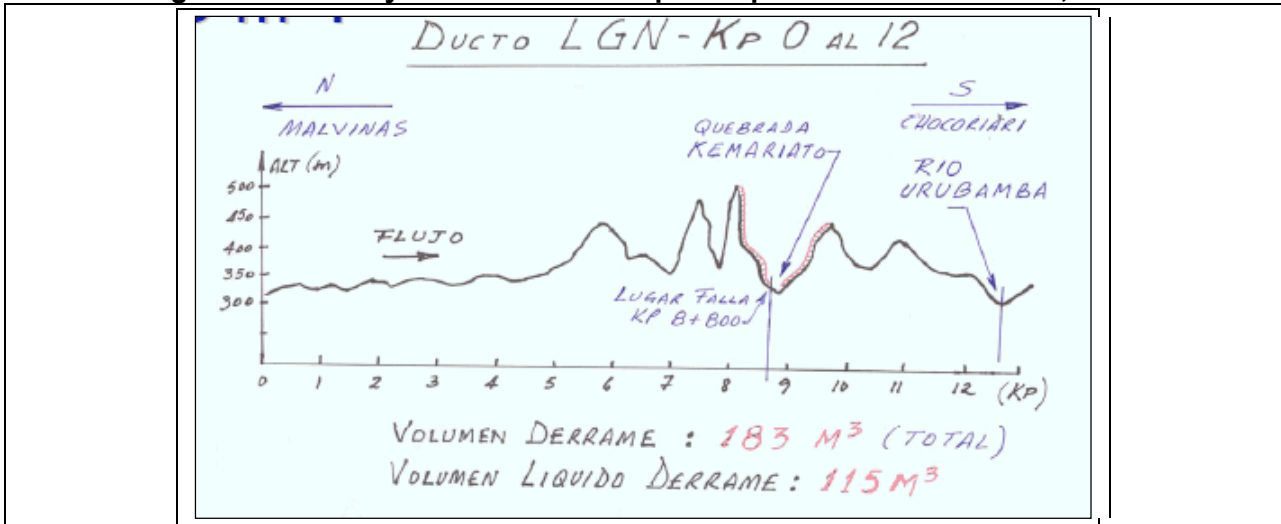


Figure 6. Quantity of Natural Gas Liquids Spilled on December 22, 2004



This rupture took place in a gorge that made the process of welding very difficult. The rupture was due to poorly executed and complicated pipe unions and landslides caused by heavy rains. A photo of the containment of in the stream adjacent to the spill is shown in Figure 7. Figure 8 shows site remediation underway following the spill. The amount of soil contaminated by the spill was approximately 300 cubic meters. These photos are from the OSINERG report on this incident (Attachment 9).

Figure 7. Containment of Liquids After Spill on December 22, 2004



Figure 8. Site Remediation After Spill on December 22, 2004





The pipe rupture is located on the “zag” portion of the weld. A close-up photo of the break is shown in Figure 9.

Figure 9. Photo of December 22, 2004 Pipe Break



Probable construction errors contributing to the pipe failure include:

- Inadequate preparation of bevels;
- In the case of a joint or Ti-Im (Ti-Im are pipe unions that are welded or connected over small rivers, gorges, or areas with limited geographic issues) the welding process may not have produced the heat necessary to ensure a quality weld;
- Inadequate handling of the pipes being welded due to strong pressure being applied to maintain the pipes in position for welding;
- Pressure overload due to soil displacement or mudslides caused by constant rains in the area;
- The generalized internal corrosion of the pipe is conducive to fissure creation;
- Landslides involve many variables including different types of soil movements, speeds, fault types, materials, and geologic factors;
- Bevels should be 35°. In the field it is not possible to accurately set this angle;
- In Ti-Im welds, the pipes were not adequately held in place to ensure an appropriate weld could be made;
- When pipe is welded, or when it is transported to the trench by heavy equipment, it is subjected to tension and flexing;
- When rain washes away soils, especially where the pipeline is located, this often causes the pipe to “float,” or lose its bracing. In the case of marsh locations ballast must be added so that the pipes remain in the pipe trench permanently (concrete ballast is one alternative).

9.2 ANALYSIS OF THE OTHER THREE FAILURES

August 29, 2005 rupture at KP 220+500 in the district of Pacobamba in Apurimac, 20 km. from the September 16, 2005 Tocate rupture (near the pump station). The rupture occurred at weld 204/65T. The rupture on this 14-inch diameter segment of the NGL pipeline was located at a six (6) o'clock orientation and was due to a defective weld. The OSINERG analysis of this spill is provided in Attachment 11.

- This weld was made in an overhead position. This type of weld is very difficult to execute;
- The weld's radiographic image was poorly analyzed during the construction phase;
- Internal corrosion was a major factor in the rupture. The corrosion propagated and originated the fissure.

September 16, 2005 rupture at Km. 200.7 km in Tocate, District of Anco, province of the Sea in Ayacucho. The rupture resulted in the dispersion of approximately 300 cubic meters (approximately 1,800 barrels) of fluid in the area. The spill reached the Chunchubamba River forcing the evacuation of 200 families from the area. Poor preparation/protection of the slopes allowed superficial and subsurface landslides to negatively impact the pipeline.

November 29, 2005 rupture. The break occurred in the section km. 50 and 52 of the right-of-way and was caused by a fissure in the weld. Also the pipeline rose to the ground surface as a result of rains. The initial spill estimate of OSINERG was in the range of 4,000 to 6,000 barrels.

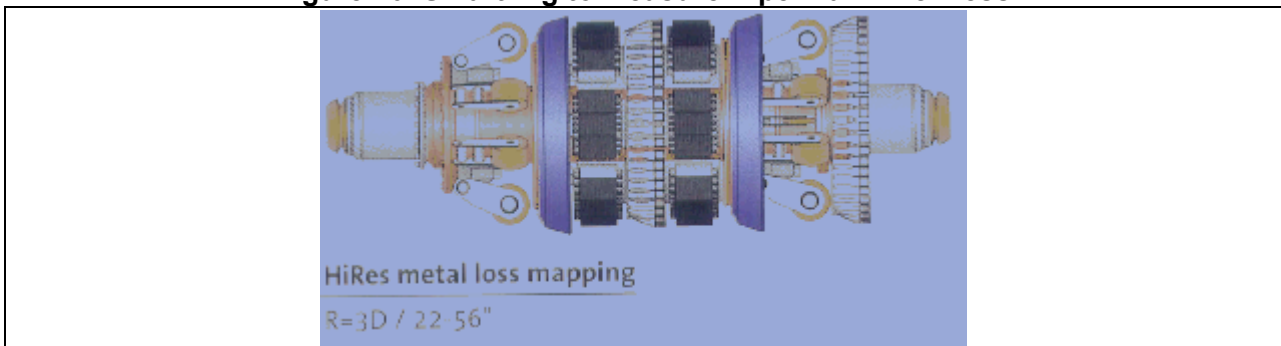
The locations of the three ruptures are located on individual topographic maps provided in Attachment 12.

9.3 POSSIBLE ACTIONS THAT COULD BE TAKEN TO FORESEE FUTURE FAILURES

- Use smart pig equipment to verify the condition and integrity of the pipeline;
- Use airborne laser optical tracking system;
- Conduct hydrostatic tests;
- Take samples of the collapsed pipe and conduct mechanical tests to determine pipe trustworthiness.

The use of the Smart Pigs is an alternative to verify the state and integrity of the pipeline. However, this equipment does not conclusively determine the thickness of the pipe. Pipe thickness verification is determined exclusively via ultrasound, that in would determine the degree of internal corrosion and wear. See drawing of a Smart Pig in Figure 10.

Figure 10. Smart Pig to Measure Pipe Wall Thickness



10.0 LOCATION OF PROBLEMATIC SECTIONS

The most problematic sections of the route are characterized by steep slopes, unstable soils, and difficult working conditions during pipeline construction. Maps of these problematic sections are provided in Attachment 13. These sections include:

Section km. 8-10

Section km. 25-52, especially:

- Paratori, km. 29
- Pongo and Ponguito, km. 42-45
- Ilcabamba, km. 52

Section km. 70-172:

- Mantalo, km. 70
- Alto Shima, km. 101
- Umpiroshiato, km. 125
- Segakiato, km. 140-141
- Comerciato, km. 150-1

Section km. 200-225

Section km. 355-370

Section km. 436-450

The first preventative step should be the complete restoration of the right-of-way (slopes) within the areas with highest rainfall and along the steepest slopes.

Concurrently an audit of the entire pipeline construction process should be conducted. This would include radiographic analysis of all welds along the entire pipeline route, conducted by certified radiographic specialists - Level III ASNT American Society of Non-Destructive Testing or of the American Welding Society AWS B5.15:2005 (interpretation).

11.0 ALTERATION OF THE ORIGINAL ROUTE WITHOUT AUTHORIZATION

The proposed original route in the environmental impact assessment (MIA) was altered due to the presence of archaeological zones or other reasons such as (1) to reduce costs and (2) in order to avoid *bofedales* (areas with large amounts of water and vegetation – similar to marshes). This caused TGP/Techint to change the route to higher elevations. This approach subject low lying areas to landslides and the resultant sedimentation of streams. A number of the route changes were properly authorized but in other cases, although the paperwork was completed by TGP/Techint, Peruvian authorities did not officially authorize the route changes. Attachment 14 includes (1) photos of the a landslide caused by a trench cut in the highlands, and (2) the line of a route change in the highlands as well.

12.0 EROSION CONTROL POLICY OF TGP/TECHINT

TGP/Techint developed specification 2794-L-SP-00062, "*Construction Specification – Erosion Control*" for the project (Attachment 15). This standard defines responsibilities as:

Construction Manager: Apply erosion control methods during construction as defined by this document.

Environmental Supervisor: Identify any need to vary from standard procedure and obtain approval or a modification from the TGP representative for any project changes.

The construction phase of the two pipelines anticipated the construction of final erosion control measures throughout the width of the right-of-way to minimize the adverse impacts of heavy rains, as well as temporary drainage control measures (especially before the rainy season). The final control measures were to be constructed in those segments of the right-of-way where the work has been completed. Particular attention was to be given to those areas subject to erosion, highly unstable soils, and with significant runoff.

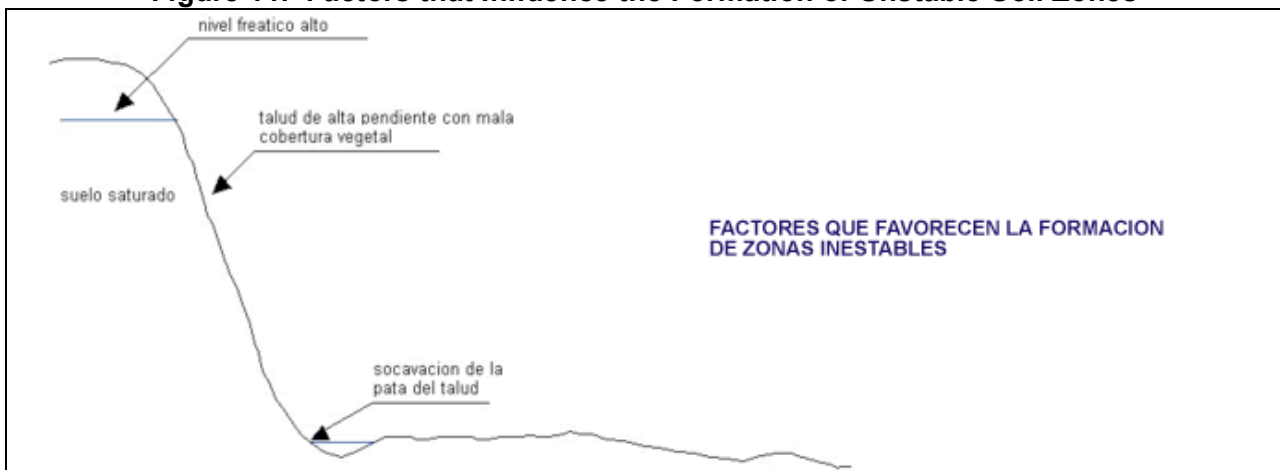
The erosion control document describes an integrated erosion control approach and defines the minimum criteria for the installation of control structures. It specifies the following minimum standards:

- Assure the stability of the right-of-way and the buried pipeline;
- Minimize risk of pollution and sedimentation to the area.
- Minimize the risk to restoration and revegetation efforts caused to unstable top soils and the subsequent removal of seeds and plants.

13.0 EROSION CONTROL POLICY OF THE MINISTRY OF ENERGY AND MINES

The Environmental Guide for Pipeline Management published by the Peruvian Ministry of Energy and Mines (Attachment 1) establishes procedures intended to minimize the environmental and operational problems associated with pipelines. Camisea pipeline containment structures in unstable areas must be constructed to resist the forces exerted by saturated soils and to transfer those forces to the structure's foundation. During landslides, these containment walls must resist the landslide's force and contain the unstable soil mass as well as transfer that force to the foundation of the containment wall.

Figure 11. Factors that Influence the Formation of Unstable Soil Zones



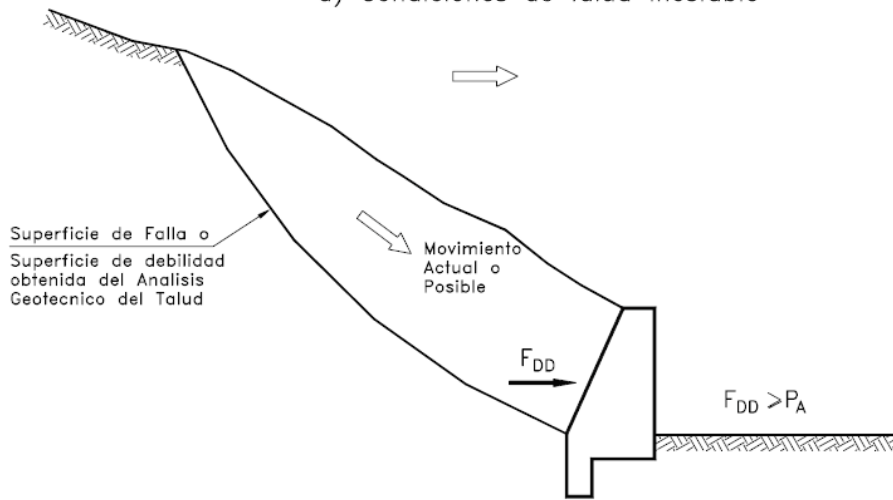
Las técnicas que hay que utilizar para estabilizar los taludes inestables son bien conocidas. Véase las Gráficas 12 a 15. La necesidad de un muro se debe a que dentro del suelo se generan unas presiones horizontales que pueden inducir a la ocurrencia del derrumbamiento o deslizamiento de una cuña de suelo relativamente subsuperficial.

La presión lateral que actúa sobre un muro en condiciones de talud estable es una función de los materiales y las sobrecargas que la estructura soporta, y los niveles de agua freática. En los casos de las zonas de selva y sierra donde hay un nivel freático que varía con las torrenciales lluvias los diseños de estas estructuras debieron basarse en la lluvia máxima.

The techniques used to stabilize unstable slopes are well known. See Graphs 12 to 15. The necessity of a wall is due to horizontal ground pressures that can cause collapse or sliding of a relatively superficial ground wedge.

Figure 12. Techniques for Stabilizing Unstable Slopes

a) Condiciones de talud Inestable



b) Condiciones de talud Estable

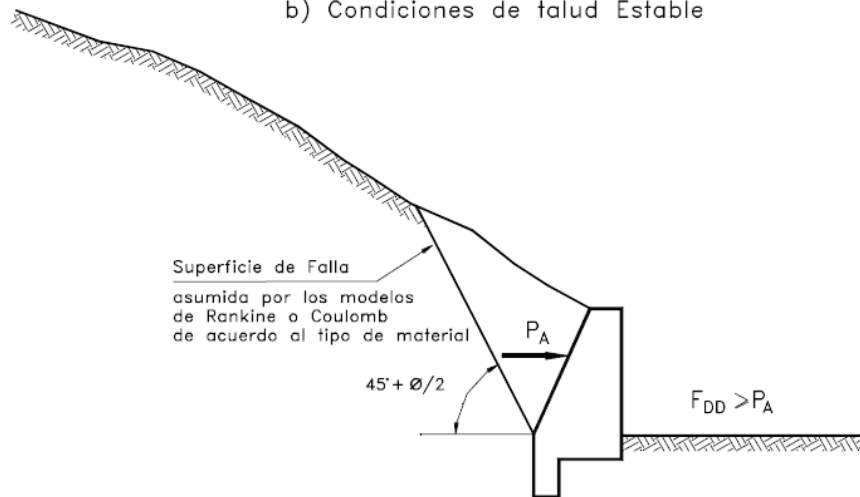


Figure 13. Sketch of Rigid Containment Walls

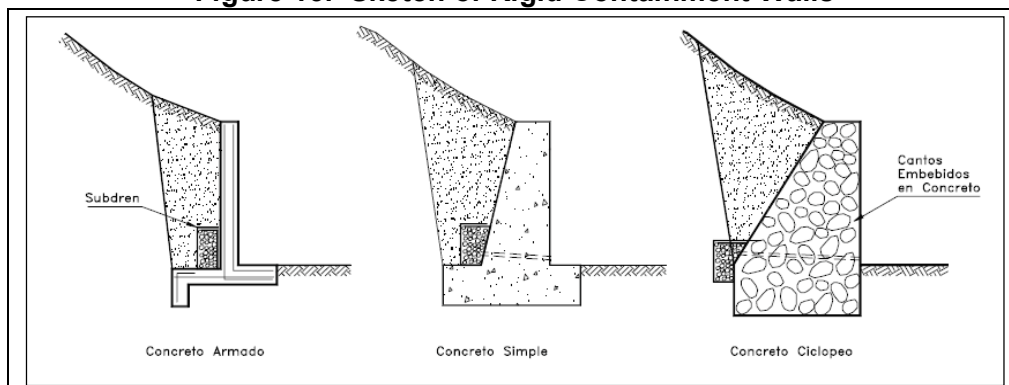


Figure 14. Sketch of Flexible Containment Walls

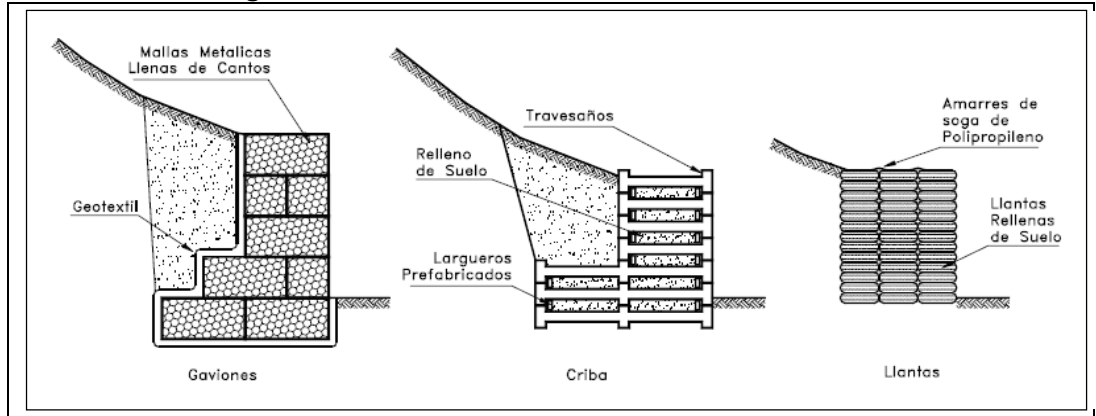
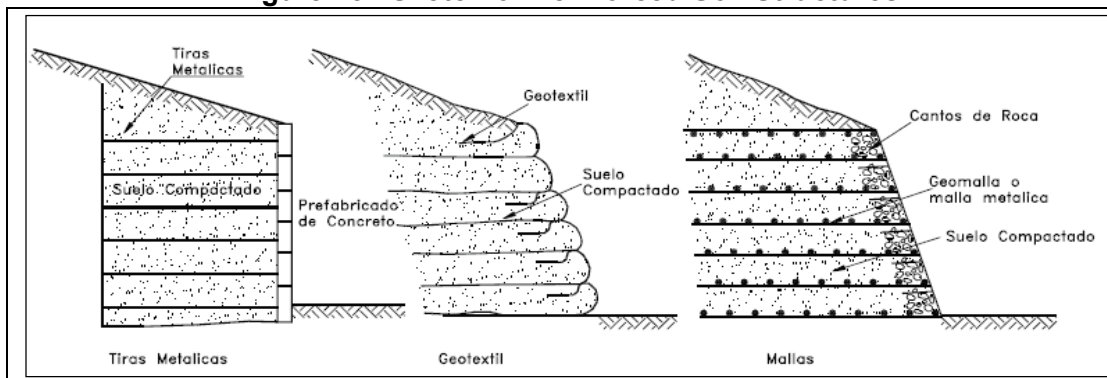


Figure 15. Sketch of Reinforced Soil Structures



Tipo	Ventajas	Desventajas
Refuerzo con tiras metálicas	Los refuerzos metálicos le dan rigidez al terraplén y los prefabricados de concreto en su cara de fachada los hace presentables y decorativos. Existen empresas especializadas dedicadas a su construcción.	Las zonas de refuerzo requieren protección especial contra la corrosión. Se requieren características especiales en el relleno utilizado con los elementos de refuerzo. Algunos tipos de muro de tierra armada están cubiertos por patentes.
Refuerzo con geotextil	Son generalmente muy económicos y fáciles de construir.	Son muy flexibles y se deforman fácilmente. Las capas de geotextil se pueden convertir en superficies de debilidad para deslizamientos. El geotextil se descompone con la luz solar.
Refuerzo con malla	La malla le da cierta rigidez al terraplén y las capas no constituyen superficies de debilidad. El efecto de anclaje es mejor.	Dependiendo del material constitutivo la malla puede descomponerse o corroerse.

Soil containment structures were constructed with geotextile reinforcements along the pipeline right-of-way. The problem with geotextiles is the tendency to deteriorate when exposed to natural light. Therefore, the geotextile material must be covered with concrete, asphalt emulsion, or vegetation. The failure of geotextile reinforcements along the right-of-way undercut

the rationale for use of geotextile as the only containment option for Camisea. It was not advisable to depend completely on geotextiles, given the geography and environmental conditions vary considerably along the pipeline route. Heavier, well-anchored structures are needed in unstable areas as well as in areas subject to heavy rains. These heavy structures are identified in the TGP/Techint erosion control specifications and the MEM pipeline construction guide.

The continued movement of soil against the pipelines increases pressures and forces that were never anticipated in the design of the pipeline or in the specification of welds for the project. The continued movement of soil threatens the integrity of the pipe welds and entire pipeline.

14.0 REALITY OF EROSION CONTROL DURING THE CONSTRUCTION PHASE

The provisional erosion control program described in the TGP/Techint erosion control document was inadequate for the conditions encountered. The erosion control document states:

The purpose of the provisional geotechnical protection work is to prevent erosion, in order to assure stability along the DDV where one pipeline is laid in one season and the other in the following dry season. These provisional erosion control works can be quickly removed to install the second pipeline and then the definitive work of protection will be carried out during the final restoration phase of the DDV. The preliminary geotechnical erosion protection measures are shown Table 1.

ITEM	DESCRIPCIÓN	UNIDAD DE MEDIDA	MEDIDA DE CONTROL Y FUNCIÓN	NOMENCLATURA
CORTACORRIENTE	Cortacorrientes con geotextil	Metro lineal	Manejo de aguas y protección de cauces	EB – GP –001
	Cortacorriente en suelo	Metro lineal	Manejo de aguas y protección de cauces en suelos arcillosos o pesados	EB – GP –002
BARRERAS DE RETENCIÓN DE SEDIMENTOS	Barreras de retención de sedimentos – Silt Fence con geotextil.	Metro lineal	Manejo de aguas y protección de cauces	EB – GP –003
ALCANTARILLAS	Tipo ARMCO de 24 y 36"	Metro lineal	Manejo de aguas y protección de cauces	EB – GP –004
PUENTES	Construidos con madera rolliza y geotextil	Metro lineal	Manejo de aguas y protección de cauces	EB – GP –005
RIP RAP	Paso enrocado o en madera utilizado en cruces de cauces	Metro cúbico	Manejo de aguas y protección de cauces	EB – GP –006
	Cuneta trapezoidal recubierta con geotextil	Metro lineal	Manejo de aguas y protección de cauces	EB – GP –007
CUNETAS	Cuneta trapezoidal suelo natural	Metro lineal	Manejo de aguas y protección de cauces	EB – GP –008
	Cuneta trapezoidal con saco suelo	Metro lineal	Manejo de aguas y protección de cauces	EB – GP –009
TRINCHOS	Trinchos en tabla - madera	Metro cuadrado	Manejo material de corte	EB – GP –010
	Trinchos en tabla con saco suelo	Metro cuadrado	Manejo material de corte	EB – GP –011

It is simple not possible to open a pipeline pathway through mountainous areas and avoid tremendous erosion without installing strong containment walls immediately upon opening the pathway. The preliminary erosion control work performed by TGP/Techint, consisting principally of sandbags and geotextiles, failed in the jungle.

15.0 CONCLUSIONS

The pipeline sections in danger of collapse are located at km 8 to 10, km 25 to 52, km 70 to 172, km 200 to 225, km 355 to 370, and km 436 to 450. These sections are located in difficult terrain characterized by pronounced curves and slopes that required the use of specialized welded joints and cross welds. Contributing factors that exacerbated the terrain challenges included: 1) unqualified welders; 2) welds executed by inexperienced welders that were promoted from assistants to welders; 3) distortions and unacceptable pressures on pipes welded while held in position by machinery during the welding process; and 4) the presence of unexpected loads on the pipe in form of landslides. Soil movement is a factor in the pipe fatigue that leads to fissures in the pipe.

At least half of the pipe used in the Camisea pipelines was left over from other projects in Ecuador and Brasil. These pipes were stored outdoors for an extended period of time. Due to the exposure, the pipes arrived in Peru with excessive corrosion that reduced wall thickness below acceptable limits required by API 1104 and ASME B31.8. The pipes also arrived with deformed bevels due to poor transportation and storage practices. The bevels had to be repaired and prepared manually in the field without proper equipment or qualified personnel prior to welding.

The pipelines require a complete audit that focuses on the pipeline construction practices that created the current problems. This audit should include radiographic analysis of 100 percent of the welds along the pipelines. The radiographic work must be carried out by qualified personnel overseen by independent inspectors. The independent inspectors should be engaged throughout the audit process to ensure the transparency of the work. Other tests of pipeline integrity, such as the hydrostatic test, intelligent pigs capable of measuring pipe wall thickness, and remote leak monitoring, such be employed at the judgement of the independent inspectors in order to comprehensively document the current condition of the pipeline(s).

Erosion control continues to be a priority. Necessary preventative actions include:

- Implementation of erosion control measures and stabilization of slopes throughout the project (especially the jungle sections);
- Restoration of the streams and river courses impacted by high sediment loads;
- Restore the right-of-way to a fully functional level;
- Inspect high-slope mountainous areas and semi-flat valleys along the route to identify those areas susceptible to erosion and landslides that must be reinforced.