APA Group

Pipeline Management System

Pipeline Integrity Management Plan
Northern Territory APA Group Assets

Document No.:					
Rev	Date	Description	Prepared	Checked	Approved
A		Draft	B. Parkin		

Version Control

This document is locally developed and maintained by the Northern Territory Engineering Manager. It is locally Controlled, but Approved nationally as per the Approvals Matrix in Volume 3 of the Pipeline Management System.

Review

The document will be subject to incremental updates and improvement which will be maintained on the Approved version in “track changes” mode to ensure that improvements are immediately available. Whenever significant change is required the document will be updated and re-Approved.

The document will otherwise be reviewed and re-Approved at least every two years with all track changes accepted into the new version.

Table of Contents

1 Introduction and Scope

1.1 Pipeline Management System

APA Group's Pipeline Management System involves a set of nationally maintained volumes which detail the asset management requirements and techniques used generically on pipeline assets.

This document is asset specific and reviews the current integrity of the assets and the maintenance requirements determined to ensure safe and reliable operations.

This document will be reviewed at least every 5 years in conjunction with the Pipeline Integrity Management Strategy and immediately following a pipeline failure event.

1.2 Assets

This PIMP relates to the following assets:

Pipeline Licence	Description
PL004	Amadeus Gas Pipeline (AGP), including the Mereenie, Tennant Creek and Katherine laterals
PL010	Elliot Lateral
PL018	Darwin to Berrimah Pipeline
PL019	Mt Todd Lateral

1.3 List of Acronyms

Below is a list of acronyms relating to this document:

AGP	Amadeus Gas Pipeline
BBM	Ban Ban Meter Station
BBS	Ban Ban Scraper Station
BGP	Bonaparte Gas Pipeline
CIMS	Channel Island Meter Station
CP	Cathodic Protection
DBYD	Dial Before You Dig
DCG	Darwin City Gate
DCVG	Direct Current Voltage Gradient
DLW	Daly Waters
ELL	Elliot
ELO	Elliot Offtake
EMS	Elliot Meter Station
ERP	Electrical Resistance Probe
GC	Gas Chromatograph
GPS	Global
HEL	Helling
ILI	Inline Inspection
KMS	Katherine Meter Station

KTH	Katherine
KTO	Katherine Offtake
MAOP	Maximum Allowable Operating Pressure
MAT	Mataranka
MER	Mereenie
MOP	Maximum Operating Pressure
MRM	McArthur River Mine
MTD	Mount Todd
MTO	Mount Todd Offtake
NCW	Newcastle Waters
PIMP	Pipeline Integrity Management Plan
PMS	Pipeline Management System
PVIC	Palm Valley Interconnect
PVL	Palm Valley
RLR	Remaining Life Review
RNS	Renner Springs
SCADA	Supervisory Control And Data Acquisition
SCC	Stress Corrosion Cracking
SMS	Safety Management Study
TCK	Tennant Creek
TCO	Tennant Creek Offtake
TMR	Tanami Road
TMS	Tennant Creek Meter Station
TTR	Ti Tree
TYP	Tylers Pass
WAR	Warrego
WCH	Wauchope

2 Integrity Based Reviews

Review	Previous	Interval	Other Basis	Next Due
Safety Management Study	2011	max 5 year	AS 2885.3	2016
Remaining Life (RLR)	n/a[1]	max 10 year	AS 2885.3	2014
Location Class	2011	max 5 year	AS 2885.3	2016
Emergency Response Manual	2013	annual	AS 2885.3	2014
Pipeline Management System	n/a[2]	max 2 years	AS 2885.3	2014
Isolation Plan		n/a	With RLR	2014
Pressure Control System		n/a	With RLR	2014
Over-pressure protection systems		n/a	With RLR	2014
MAOP / MOP	2006	n/a	This is now the RLR	n/a
Fitness for Purpose	2009	n/a	As information becomes available	n/a
Hazardous Area Inspection	2012	As necessary	AS 2885.3	
Fracture Control Plan	2011	n/a	AS 2885.1	

3 Other reviews

Review	Previous	Interval	Other Basis	Next Due
Corrosion Management Plan		10 year		
Maintenance Planning	Not currently performed			
SCC Management Plan			N/A	

[1] Remaining Life Reviews are a new AS2885 requirement. MAOP reviews have been conducted previously.

[2] This has previously been referred to as the Pipeline Management Plan, which is currently in place.

4 Integrity Reporting

Report	Previous	Interval	Other Basis	Next Due
Cathodic Protection	2012	annual		2013
Coating Refurbishment	2012 (DDS pipeline only)	Annual (DDS pipeline only)		2013
Land Management Report – (encroachment, liaison, environment, surveillance)	Encroachment is reviewed as a result of the monthly aerial patrols. Easement ground surveillance is performed at least annually			
Maintenance and Inspection Report		Monthly		
Rotating Plant Report	No rotating equipment exists for these licences.			

5 Review of local management factors

5.1 Regulatory Requirements

Pipeline licence 18 (for the Darwin to Berrimah pipeline) plus licence 19 (for the Mt Todd pipeline) specifies that annual coating surveys should be performed using DCVG on areas highlighted by the annual cathodic protection survey (licence 18 paragraph 31 and licence 19 paragraph 29).

Pipeline licence 19 states that the licencee shall review the maximum allowable operating pressure of the pipeline every five years (paragraph 22).

Pipeline licence 19 states that the annual survey of the cathodic protection system should be conducted by an independent organisation (paragraph 27).

There are no other specific regulatory requirements for these pipelines.

5.2 Owner Requirements

There are no specific owner requirements for these pipelines.

6 Specific integrity factors

6.1 SMS outcomes – integrity related mitigation

The SMS for these pipelines was last conducted in 2011. Refer to the full report for all actions to come out of this study. A list of specific actions are shown below in Table 1.

Table 1. SMS Actions

ID	Action	Status	Closing Comments	Threats Location	Threat
4	Coating disbondment - include inspection for disbondment in all dig-ups; also include coal tar epoxy coating in stations	closed	Disbondment carefully inspected during all digups. Station recoating project has been implemented.	Non-location-specific	Cathodic disbondment (high CP potential)
8	Corrosion on unpiggable pipelines - consider dig-ups at random locations to check for disbonded coating with shielded corrosion	closed	Several girth welds were excavated and inspected on the Channel Island spur during the DCVG repair project.	Non-location-specific	Undetected metal loss - unpiggable section of pipeline
19	Cover at Mereenie Rd - check depth of cover at parallel section, KP 0.63 - 1.0	open		Parallel road; Pipeline is under the road from bend at KP0.629 for 350m.	Road parallel and over pipe
21	Union Reefs dam - arrange DCVG etc when dam water level low	Open		Dam, Union Reefs mine. KP1330.8 to KP1331.6	Pipe under water, no access for inspection or repair
24	Coulton Park area - update alignment sheets, all new development is missing	Open		Acacia - Hughes rural residential area; no features on alignment sheets. KP1473 to KP1479.	Rural residential and horticulture development
25	Coulton Park area - review patrol frequency in this more populated area, consider weekly ground patrol	Open		Acacia - Hughes rural residential area; no features on alignment sheets. KP1473 to KP1479.	Rural residential and horticulture development
26	Channel Is bridge - consider running new pipe between bridge beams to eliminate threat of vessel impact; if not possible, consider other protection against vessel impact	Open	Special Projects will include a risk assessment of these risks in assessing design options.	Channel Island Bridge. KP1512.0 to KP1512.5.	Vessel impact on aboveground pipe
27	Bridge crossings - consider regular inspection of exposed pipe for corrosion and coating condition, including gas detection at bridge abutments; should be scheduled soon as proper inspection has not been done for some time	open		Channel Island Bridge. KP1512.0 to KP1512.5.	Corrosion of aboveground pipe
28	Channel Is replacement pipe - consider heavy wall thickness to resist bullets or vessel impact	open	Special Projects will include a risk assessment of these risks in assessing design options.	Channel Island Bridge. KP1512.0 to KP1512.5.	Vandalism of aboveground pipe, including shooting
30	Planning schemes - maintain regular contact with local and territory government planning departments to ensure they are aware of the pipeline and the implications of a pipeline failure for nearby	open		Non-location-specific	Long term urban development planning

ID	Action	Status	Closing Comments	Threats Location	Threat
	residents, and develop plans accordingly, particularly for proposed Weddell city; consider participation in APIA Corridor Committee				
31	Mines & mineral leases - improved pipeline awareness required for lease holders; investigate effective means of identifying and liaising with lease holders who are or may become active	open		General installation - RURAL	Mine development, including mineral exploration and construction of mine facilities

6.2 Remaining Life Review – integrity related mitigation

A remaining life review has not yet been completed for the pipeline licenses in this document. This is due for completion in 2014.

6.3 Corrosion

6.3.1 *Inline Inspection*

Inline inspections have been performed as per the history shown in Table 2.

Table 2. Inline Inspection History

Size (inch)	Section	1993	1997	1998	1999	2003	2008	2009	2010	2013	2014
10	MER-TYP			Y				Y			
14	PVL-TMR		Y				[3]				Y
	TMR-TTR		Y				Y				
	TTR-WCH		Y				Y				
	WCH-WAR		Y				Y				
	WAR-RNS		Y				Y				
	RNS-NCW		Y				Y				
	NCW-DLW		Y		Y[4]		Y				
	DLW-MAT		Y				Y				
12	MAT-HEL	Y				Y				Y	
	HEL-BBS	Y				Y				Y	
	BBS-DCG	Y				Y		Y[5]	Y[6]		
8 & 12	DCG-CIMS	Intelligent Pigging has never been performed									
4	TCK Lateral	Intelligent Pigging has never been performed									
	KTH Lateral	Intelligent Pigging has never been performed									
3	ELL Lateral	Intelligent Pigging has never been performed									
8	MTD Lateral	Intelligent Pigging has never been performed									
6	DDS Lateral[7]	Intelligent Pigging has never been performed									

All inspections performed up to and including 2010 were conducted from south to north. Inspections performed from 2013 onwards were conducted from north to south.

Table 3 shows the schedule for future inline inspections.

[3] Inspection could not be performed between PVL and TMR in 2008 as gas flows were too low.

[4] This was a rerun of the 1997 inspection due to data problems.

[5] Inspected as part of the early gas project.

[6] Inspected as part of the early gas project.

[7] A review is currently inderway to determine whether it is possible to inspect this pipeline.

Table 3. Inline Inspection Schedule

Size (inch)	Section	Most Recent	Next Inspection Due					
			2017	2018	2019	2020	2023	2024
10	MER-TYP	2009			Y			
14	PVL-TMR	2014						Y
	TMR-TTR	2008		Y				
	TTR-WCH	2008		Y				
	WCH-WAR	2008		Y				
	WAR-RNS	2008		Y				
	RNS-NCW	2008		Y				
	NCW-DLW	2008		Y				
	DLW-MAT	2008		Y				
12	MAT-HEL	2013				Y		
	HEL-BBS	2013					Y	
	BBS-DCG	2010				Y		
8 & 12	DCG-CIMS	N/A	Y[8]					

All 10 inch and 14 inch sections are scheduled for ten year inspection frequencies. Immediately following the 14" inspection in 2008, the quantity of detected features resulted in the inspection interval reducing to seven years. However, a review of all data by Michael Brown (APA Group), concluded that inspection frequencies can be extended back to ten years for all sections. Michael Brown recommended an additional seven excavations between Wauchope and Warrego to ensure this frequency can be extended to ten years.

For the 12 inch sections, the Helling to Ban Ban Springs and Ban Ban Springs to Darwin City Gate sections all have a relatively low quantity of corrosion. Pigging frequencies remain at ten years for these sections. The Mataranka to Helling section does have a problem with regard to heat shrink sleeves. An assessment of expectant failure using estimated corrosion growth rates by GE following the 2013 inspection showed an exponential increase in the number of failures starting in 2022 (refer to Table 4). With this in mind, Michael Brown has recommended that this section have a seven year inspection frequency.

Table 4. Feature Failure Rate of Helling to Mataranka Section

Year of Failure	Number of Features
Immediate (based on inspection in 2013)	44
2014	3
2015	1
2016	2
2017	7
2018	4
2019	5
2020	7
2021	19
2022	95
2023	119

8 Pending completion of the Channel Island Bridge Project. May be inspected as one 12" section, or a broken up into a 12" section and an 8" section.

The Darwin City Gate to Channel Island section is expected to have a ten year inspection frequency. This frequency should however be reviewed once results of the first inspection are received.

APA Group / NT Gas utilised Rosen for inline inspections between 1997 and 2010 inclusive. PII (GE) were utilised for inspections in 2013 and 2014. The GE inspections were performed from a north to south direction following the change in pipeline flow with the introduction of the Bonaparte Gas Pipeline. The change in pipeline dynamics with introduction of the BGP meant that gas flows south of Ban Ban Springs were extremely slow. The performance of the 2013 GE tool was relatively slow, but this was improved for the 2014 inspection between Tanami Road and Palm Valley.

6.3.1.1 *Recommendations for future Inline Inspection programs*

It is recommended to conduct pigging between Mataranka and Tanami Road using a similar GE tool configuration to what was used in the 2014 inspection between Tanami Road and Palm Valley. Performance of this tool was significantly better than the performance of the tool between Ban Ban Springs and Mataranka in 2013. Due to the long run times expected, these inspections may need to be conducted over two dry seasons.

The bidirectional pigging project manufactured a portable pressure reduction skid that can be installed at each scraper station. Use of this is recommended in order to increase linear gas velocity and pig speed.

Careful consideration should be given to pipeline dynamics with potential new gas suppliers at the southern end of the pipeline. These additional suppliers may result in gas flows that are too low for pigging to take place.

6.3.2 *Heat Shrink Sleeves*

The AGP is protected by SHAW yellow jacket coating and CANUSA heat shrink sleeves across all girth welds. Protected is also provided by numerous impressed current cathodic protection units. Results of intelligent pigging indicate that the majority of corrosion detected on the pipeline exist beneath failed girth weld sleeves. When these sleeves fail, moisture is able to penetrate the coating, but impressed current from cathodic protection is not able to provide protection. This also means that faulty sleeves cannot be detected through DCVG surveys. Therefore corrosion is experienced regardless of the cathodic protection level of the pipeline. The majority of the failed heat shrink sleeves are between Renner Springs and Mataranka as shown in Table 5.

Table 5. Percentage of welds where at least one corrosion defect was detected by the intelligent pig with a depth greater than or equal to 10%

Section	Percentage of welds with at least one corrosion feature greater than or equal to 10% in various inspection years.				
	1997	2003	2008	2009	2013
MER-TYP				0.0	
PVL-TMR	0.3		n/a[9]		
TMR-TTR	0.2		0.0		
TTR-WCH	0.2		0.0		
WCH-WAR	0.5		0.1		
WAR-RNS	0.2		0.2		
RNS-NCW	1.3		5.9		
NCW-DLW	8.8		27.4		
DLW-MAT	5.1		21.1		
MAT-HEL		2.6			22.5
HEL-BBS		1.4			2.3
BBS-DCG		3.0		5.6[10]	
DCG-CIMS	Intelligent Pigging has never been performed				
TCK Lateral	Intelligent Pigging has never been performed				
KTH Lateral	Intelligent Pigging has never been performed				
ELL Lateral	Intelligent Pigging has never been performed				
MTD Lateral	Intelligent Pigging has never been performed				
DDS Lateral	Intelligent Pigging has never been performed				

Following completion of 14" intelligent pigging in 2008, IONIK Consulting was utilised to assess the numerous corrosion defects that were detected. In this report, IONIK determined defect growth rates for each pipeline section, then determined timeframes in five year blocks for when individual corrosion defects were expected to fail. This prioritisation system has been the basis for many rosters of metal loss digups on the 14" pipeline, particularly between Renner Springs and Mataranka.

Field inspections of the defects as per the IONIK report have indicated that there has been a consistent inaccuracy in how the pigging contractor has measured certain types of features. Rosen reported many corrosion features as having a long length (ie in the order of 100mm), but a shallow depth (ie in the order of 5-9%). When features of these dimensions are grown in both length and depth, it doesn't take long until they fail the defect assessment criteria. The IONIK prioritised defect list had many features reported to be less than 10% in the 2008 reports. However, field inspections determined that the dimensions reported by Rosen typically didn't meet what was found in the field. The feature area reported by Rosen typically wasn't of the long length that was reported. Therefore, features on the IONIK list that are less than 10% will not be investigated. Features will be re-evaluated following the next inspections on the 14" line in 2015. Refer to document *Corrosion Repair Priority Report*.

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[9] Pigging could not be conducted on this section in 2008 as gas flows were too low.

[10] Pigging was conducted between Ban Ban Springs and Darwin City Gate out of sequence due to the early gas project. Inspections took place in 2009 as a baseline and again in 2010 to determine whether any damage was caused on the pipeline. Results in 2009 and 2010 were very similar.

Future inline inspections are expected to be assessed with the Integrity Data Management Tool (Uptime). Specific corrosion growth rates will be determined either through this project or in the APA Group ILI Policy.

The majority of corrosion on the AGP is a result of failed heat shrink sleeves placed over girth welds at construction. Heat shrink sleeves were also placed over defects of the SHAW yellow jacket coating at construction. Failures in this application has led to some levels of corrosion at these former coating repairs. Identifying corrosion of this type can be performed through inspection of intelligent pigging reports.

The majority of other corrosion is associated with defects in the yellow jacket coating. A split in the coating may cause adjacent coating to disbond, and shield the pipe from cathodic protection current. Intelligent pigging data aligned with DCVG data (where available) has assisted to locate this type of corrosion feature.

6.3.3 *Digups*

Digups have been historically performed to inspect features found in both DCVG surveys and intelligent pigging. As per section 6.4.2 however, DCVG surveys are no longer performed in piggable NT pipelines. The following sections outline how excavations will be scheduled for both piggable AGP sections and for unpiggable AGP sections.

6.3.3.1 *AGP Digups*

As per section 6.3.2, the majority of corrosion issues on the AGP are the result of failed heat shrink sleeves. A significant number of repairs have taken place following the prioritisation performed by IONIK based on the 2008 data. As of February 2015, all features expecting to fail within 15 years of the 2008 ILI have been inspected (refer to Table 6). All features estimated to fail between years 16 and 20 have been inspected except for one[11]. The remaining excavations are expecting to fail from year 21 onwards. With such a significant amount of work already performed on 14” digups, there is little value in continuing these digs until the next ILI in 2018 (refer to Table 3). Prioritisation can be readdressed based on this new data set.

[11] The one feature that has not yet been inspected is in the Tanami Road to Ti Tree section. No digups have taken place in this area for several years.

Table 6. Digup Status from 2008 ILI based on IONIK prioritisation (as of Feb 2015).

Repair Block (years from 2008)	Digups required based on IONIK prioritisation[12]	Digups Completed[13]	Digups Outstanding
0	0	0	0
1-5	0	0	0
6-10	13	13	0
11-15	96	96	0
16-20	206	205	1
21-25	340	145	195
26-27	161	24	137
28	88	3	85
TOTAL	**904**	**486**	**418**

As per Table 4, a number of features have been identified for excavations following the 2013 inspection between Mataranka and Helling. These locations were prioritised by utilising a LAPA assessment (Length Adaptive Pressure Analysis) by GE. This assessment is similar to an RSTRENG assessment, in which a burst pressure is determined for each corrosion cluster. It is this burst pressure that should be used as a digup prioritisation criteria. As stated in section 6.3.1, digups should be completed such that features estimated for failure up to and including 2021 are completed prior to the next ILI in 2020.

Digups in Tanami Road to Palm Valley section will be assessed once the final reports are received by GE.

Table 7 below summarises all digups required up until 2020. Digs are required annually based on DCVG results betwteen DCG and CIMS, plus the DDS pipeline. These have been included for 2015, but not for future years.

Table 7. Yearly Digup Summary

Year	Dig Location Required	Quantity
2015	DCVG digups between DCG and CIMS	6
	DCVG digups on DDS	8
	Wauchope to Warrego, based on 2008 ILI. Required to extend pigging frequency in this section back to ten years (refer to section 6.3.1).	7
	Helling to Mataranka, based on 2013 ILI. This could be delayed until 2016, however it should be more economical to perform these digs with the other digs scheduled in 2015.	44
	Verifcation digups between Tanami Road and Palm Valley based on 2014 ILI.	5
2016	Digups based on 2014 ILI between Tanami Road and Palm Valley.	unknown

[12] These numbers are after a reprioritisation occurred by APA Group where features less than 10% were not considered for repair. Refer to section 6.3.2.

[13] The IONIK dig list did not include digs that had already been completed prior to 2008. This list does not include all digs completed after 2008, since some were completed prior to the 2008 ILI.

Year	Dig Location Required	Quantity
2017	Verification digups between DCG and CIMS	5
2018	Digups between DCG and CIMS	Unknown
2019	Verification digups between Mataranka and Tanami Road based on 2018 ILI	35 (5 in each of the 7 sections)
2020	Mataranka to Tanami Road digups	unknown
	Verification Digups between Mereenie and Tylers Pass based on 2019 ILI	5

6.3.3.2 *Channel Island Spur and Darwin Distribution Digups*

As per section 6.4.2, DCVG surveys will continue to be performed annually on both the Channel Island Spur and the Darwin Distribution System. All coating defects greater than 1%IR should be excavated and inspected. For every excavion, one heat shrink sleeve should be removed to assess the existence and severity of corrosion on this pipeline.

DCVG surveys will no longer be required on the Channel Island Spur once the pipeline is modified to allow pigging to take place. Excavations will then be prioritised and performed the same as the AGP.

6.3.3.3 *Unpiggable Lateral Digups*

As per section 6.4.2, DCVG surveys will continue to be performed on unpiggable laterals on a five-yearly basis. All coating defects greater than 1%IR should be excavated and inspected. For every excavion, one heat shrink sleeve should be removed to assess the existence and severity of corrosion on this pipeline.

6.3.4 *Corrosion Assessment*

Where possible, assessment of corrosion on a digup should be performed with a laser scanner. The general parameters for the laser scanner assessment should be as follows:

- Scan resolution: 1.00mm
- Pit Gauge Parameters:
  - Center: 50.80mm
  - Extension: 25.40mm
  - Maximum extensions: 5
- Interaction Parameters:
  - Axial criteria: 3 x WT *
  - Circumferential criteria: 1.5 x WT
  - Critical Factor: 10%
  - Threshold: 5%
  - Interaction Method: Connecting Box
- Design Factor: 0.72

The assessment for a scanner requires the user to manually exclude the girth weld from the assessment area. Care should be taken such that all of the girth weld is removed, as even a tiny amount of remaining weld will influence the results.

If any feature in this assessment has a safety factor of less than or equal to 1.39[14], then a mechanical repair should be applied. This should either be a Weldwrap (for corrosion at a girth weld), or a clockspring repair for mid-pipe corrosion.

If any feature in this assessment has a safety factor of between 1.39 and 1.42, a close inspection should be made of the feature, particularly the actual weld. The laser scanner is not able to detect corrosion in the girth weld. If corrosion is present in the actual weld material, an additional assessment should be performed with the axial criteria extended to 4 x WT. Doing this means that the interaction is more likely to cross over the girth weld, and is a way to accommodate for the corrosion in the weld. If the 4 x WT assessment has a safety factor of less than or equal to 1.39 and there is corrosion in the weld, a mechanical repair should be strongly considered.

If assessing corrosion with no laser scanner, a pit gauge should be used. A riverbed profile should be measured at 5mm longitudinal increments to determine the worst case corrosion profile along the corrosion feature. RStreng software should then be used to determine the corrosion severety.

6.3.5 *Stress Corrosion Cracking (SCC)*

Buried steel pipeline with high operating pressure are more susceptible to SCC. The majority of metal loss inspections performed since 2009 have involved testing for SCC. No evidence of SCC has been found.

6.3.6 *Cathodic Protection*

The corrosion control system for the AGP is operated and maintained to meet or exceed the guidelines laid out in the latest revisions of AS2885.3 Pipelines-Gas and liquid petroleum Part 3: Operation and maintenance and AS2832.1: Cathodic Protection of Metals; Part 1: Pipes and Cables.

Surveys and corresponding reports are conducted annually on the cathodic protection system. 5 electrical resistance probes exist in each mainline pipe section. These probes are checked every 2 months, and give an indication regarding the effectiveness of the cathodic protection in this area.

Refer to annual reports for specific cathodic protection issues, including recent augmentations to the Cathodic Protection and plans for future systems.

6.3.7 *Internal Corrosion*

The gas transported by the AGP does not generally contain chemical compositions that would result in internal corrosion.

Gas delivered by the Bonaparte Gas Pipeline in the first few months of this pipeline's operation in 2009 had a high moisture content. This was known as "early gas", and only flowed in the AGP from Ban Ban Springs to Channel Island[15]. Intelligent pigging was performed between Ban Ban Springs and Darwin City Gate both before and after the early gas project to determine whether internal corrosion had taken place on this section. No internal corrosion was detected.

Although filtration and liquid extraction took place at Darwin City Gate during the transportation of early gas, there is a possibility that this potentially corrosive gas was present

[14] This safety factor is the estimated failure burst pressure of the feature divided by MAOP. The 1.39 criteria is the inverse of the pipeline design factor.

[15] The Main Line Valve was closed at Ban Ban Springs during early gas to prevent potentially corrosive gas flowing south. Southern demand was met with supply from Palm Valley and Mereenie.

on the Channel Island Spur. As stated in section 8, plans are underway to replace the smaller diameter pipe section across the Channel Island bridge to make this section piggable. When it is, attention should be paid to potential internal corrosion.

6.4 **Other Factors**

6.4.1 *Earthquakes*

On the 22nd of January 1988, two years after commissioning of the AGP, three large earthquakes occurred at Tennant Creek. These earthquakes were magnitude 6.3, 6.4 and 6.7, and severely buckled the AGP (refer to Figure 1). Since 1988, many minor tremors have been experienced on areas of the AGP, predominantly around Tennant Creek. Refer to Figure 2 for an overview of earthquake activity locations in the Northern Territory in proximity to APA pipelines.

Figure 1. Buckling on the AGP caused by the TCK earthquake

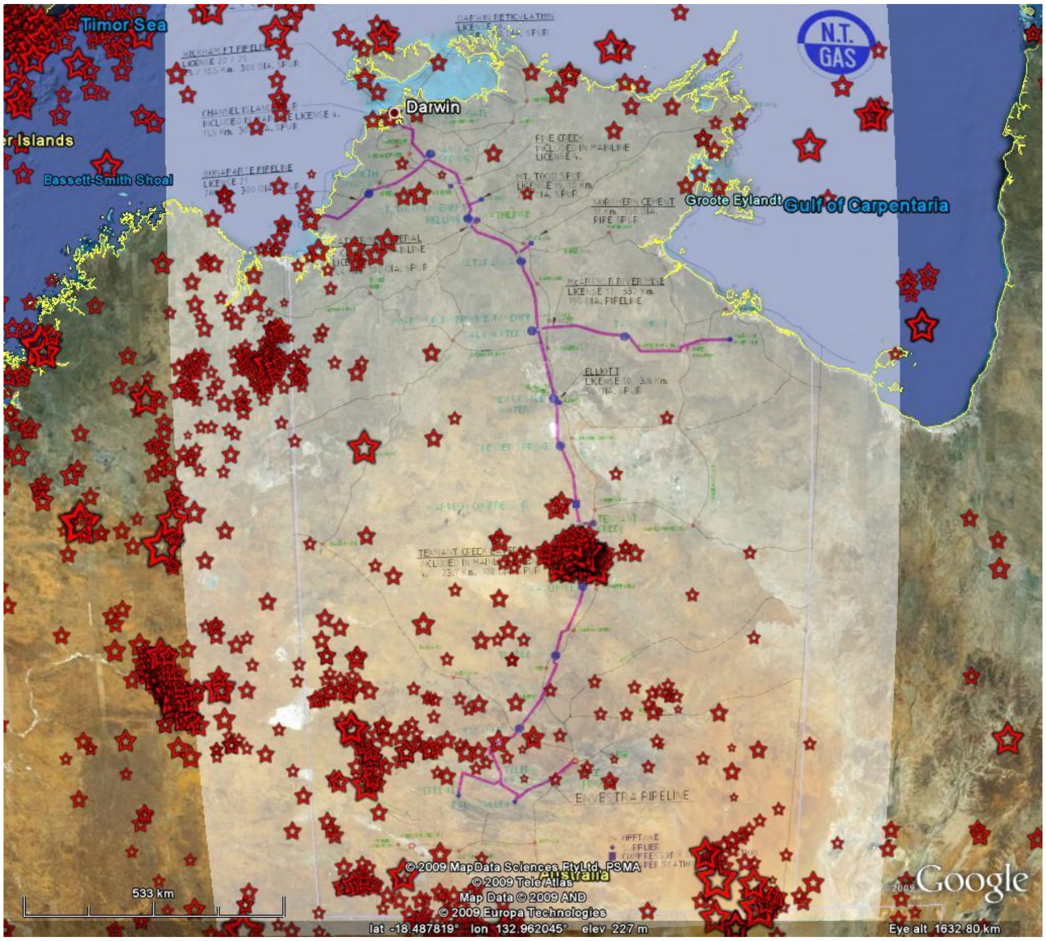

Figure 2. Earthquake activity in the Northern Territory (data collected in 2009)

APA Group NT monitor earthquake activity on a monthly basis via the Geoscience Australia website. Any earthquake of a significant magnitude or proximity to the pipeline will be investigated, possibly with a gauge or calliper pig.

6.4.2 *Coating Surveys*

Historically, coating surveys have been conducted on all APA Group NT pipelines. Direct Current Voltage Gradient surveys (DCVG) have been conducted on a five year rolling cycle. Coating defects greater than 15%IR were inspected and repaired to check for metal loss and to limit the demand on the cathodic protection system.

In recent years, APA Group have implemented policies where DCVG surveys are no longer considered a routine method for integrity assessment. As per this policy, they should only be performed for unpiggable pipelines, or as required to meet individual licence requirements. Refer to Table 8 for a schedule of DCVG surveys.

Table 8. DCVG Survey Schedule

Pipeline	DCVG Last Completed	Next DCVG Scheduled	Comments
Darwin City Gate to Channel Island	2014	2015	Survey conducted annually
Darwin Distribution System	2014	2015	Survey conducted annually
Tennant Creek Lateral	2010	2015	
Elliott Lateral	2013	2015	Although this gap will be only 2 years, it is more efficient to complete the survey in 2015 while the Tennant Creek survey is also being completed.
Katherine Lateral	2012	2017	
Mount Todd Pipeline	2012	2017	
All unpiggable station pipework, including blowdowns.	Various	TBD	Date for this work to be determined in consultation with operations and the below ground station recoating phase 2 project.

Historical DCVG records should be considered with intelligent pigging reports to assist with locating and assessing potential metal loss.

6.4.3 *Below Ground Station Recoating*

In 2012, five Scraper Stations and four Main Line Valves were excavated to determine the condition of the below ground station coating and pipework. This process identified several areas of coating deterioration and subsequent corrosion. Plans are underway to excavate and recoat all remaining AGP stations. Note that the scope of this project does not include recoating of stations associated with either the Darwin to Berrimah or Mt Todd pipelines.

6.4.4 *Anchor Blocks*

DCVG surveys have identified numerous scraper stations with coating defects inside the anchor block at the extreme ends of the station. In 2012, anchor blocks with known defects were investigated using ultrasonic testing to determine whether the coating defect was responsible for any corrosion. No corrosion was found as a result of this project. However, since the anchor blocks were not physically removed, the coating defects that were originally identified will still exist.

6.4.5 *Lightning strikes at facilities*

Direct lightning strikes to the pipeline are rare but they do happen. A more common occurrence than direct lightning strikes to the pipeline is a Lightning Electromagnetic pulse (LEMP). This is where a longitudinal voltage is induced in the pipeline due to a lightning strike to earth in the vicinity of the pipeline.

In both cases, a low impedance, underground earth drainage point is required at each end of the pipeline section to prevent above ground pipework and equipment developing a high potential difference with respect to the remote earth.

Surge currents caused by LEMP are effectively drained to earth using the station earth grids. Polarisations Cells and/or Surge diverters are used at the end of each pipeline section (the section between two stations) to protect the insulating joint. These work by becoming conductive in the presence of a high voltage to divert lightning surge or power utility fault currents around the insulating joint.

Lightning Protection Systems (LPS) are designed to protect both the station hardware and personnel. They consist of an air terminal, an earth terminal and a high capacity, low impedance connection between the two. In most cases on APA stations the earth terminal is the station's Main Earth Grid. However, in many stations earth mats are used to minimise the potential difference between above ground pipework and the adjacent ground thus limiting both step and touch potentials. Earth mats also improve the ground terminal's capacity to effectively deliver large amounts of energy to earth quickly. On some stations an additional, dedicated earth stake is connected directly to the air terminal.

At stations where a dedicated air terminal is used it is a metallic sphere mounted on a pole, several metres above the stations

Surge Protective Devices (SPD's) are installed to protect critical and/or expensive electrical equipment by shorting lightning surge currents to the station earth grid.

6.4.6 *Lightning strikes on the pipeline*

Direct lightning strikes to the pipeline can potentially damage the pipeline through a combination of high levels of kinetic, electrical and thermal energy. A direct lightning strike on the pipeline typically leaves a small Conical defect in the pipe wall with localised coating damage at both the entry and exit point. If enough energy is involved in the lightning strike, the depth of the conical defect in the pipe wall can exceed the wall thickness and result in a pinhole leak. Effective protection of the pipeline against direct lightning strike is cost prohibitive, fortunately the occurrence frequency is very low.

APA Group NT has experienced numerous lightning strikes affecting the AGP. Two of these lightning strikes resulted in loss of containment requiring immediate repair. Other lightning strikes have caused significant damage to the pipeline also requiring repair.

Lightning strikes have been identified by a variety of methods:

- Intelligent Pigging. Typically, lightning strikes show a unique signature in the metal loss profile from intelligent pigging. They are typically close to the 12:00 position of the pipe, show a significant depth, and have a very short length and width. Comparing the survey results to previous pigging results may show a signifcant defect appearing when previously there was none. By comparison, corrosion usually appears more gradually over time. Typically the maximum depth of a lightning strike is far greater than what is reported by an intelligent pig.
- Coating surveys. One lightning strike was found due to the excavation of a coating defect. This strike was on the DCG-CIMS section, which cannot be pigged anyway. The size of the coating defect was small (ie less than 5%IR), which would generally not have been excavated anyway. Small coating defects were excavated on this section because the pipeline could not be pigged (refer to section 8).
- Notification by the public. One[16] lightning strike has been found on the AGP due to a report from a member of the public. In this instance, a significant noise was created by the loss of gas containment, which was reported to APA Group.

There is very little that can be done to prevent lightning strikes from occurring. APA Group examines all pigging reports carefully to check for any lightning signatures. APA Group also responds to all enquiries by members of the public with regards to unusual odour or noise around the pipeline easement. Odorant is injected into the AGP at Ban Ban Springs. Based on flow conditions in 2013, all sections of the AGP are odorised except for the Mereenie Spur.

6.4.7 *AC Corrosion*

[16] A lightning strike was also reported on the McArthur River Mine (MRM) pipeline by a member of the public. In this instance, this person contacted APA Group reporting the smell of gas in the area. The MRM pipeline is covered under a separate licence and PIMP.

Mitigation against AC Corrosion is as follows:

6.4.7.1 *AGP (DCG to CIMS)*

- Polarisation cells at DCG and CIMS
- Ground bed at KP 1506
- Zinc earthing either side of Channel Island Bridge (KP1509 and 1510), decoupled with polarisation cell
- Electrical isolation at DCG (currently cross bonded due to depleted ground bed at KP1506)

6.4.7.2 *Katherine Lateral*

- Twenty 1.5 m zinc ribbons at locations where the pipeline is parallel to power lines

6.4.7.3 *Darwin to Berrimah Pipeline*

- Polarisation cells at DCG and Berrimah Offtake
- Magnesium anodes at every second test point. While these will dissipate AC current, they are not as effective as zinc)

6.4.7.4 *Mt Todd*

- Polarisation cells at offtake and delivery station, along with zinc earthing
- Polarisation cell and zinc ribbon at ~KP6
- There are magnesium anodes at every second test point which will dissipate AC current to an extent, but not as well as zinc

Monitoring of AC corrosion is by determined by the requirements of AS 4853. Spot AC measurements are taken on the annual CP surveys. The assessment criteria is as per AS 4853, which has recently been revised from 15 VAC to:

- 4 VAC for soil resistivity ≤ 25 Ωm
- 10 VAC for soil resistivity > 25 Ωm

6.4.8 *Erosion*

The Amedeus Gas Pipeline route extends through flood prone areas and crosses drains and watercourses with the potential for erosion. Some sections of the pipeline (such as Lake Woods from approximately KP800 to KP820) traverse terrain that is covered with water for a large portion of the year. Subsequent exposure and flotation of the pipeline is considered a possible consequence. Erosion on the AGP, including all water and road crossings, is monitored through monthly aerial patrols and annual Right of Way patrols.

6.4.9 *Fires*

Portions of the AGP experience fires on a regular basis. Pipeline marker signs damaged by fire should be replaced where possible. Fire breaks should be placed surrounding stations to restrict damage to station pipework and equipment.

7 Risk Mitigation

7.1 **Encroachment**

Pipeline encroachment is monitored through procedural measures including Dial-Before-You-Dig, landowner liaison, aerial patrols and regular pipeline ground patrols. The 2011 SMS identified that the section of pipeline with the highest risk to encroachment was the Coulton Park section between KP1473 and KP1479, due to residential developments (refer to ID 25 from Table 1). A recommendation was made in the SMS to conduct weekly pipeline patrols in this area. This weekly patrol is performed by operations.

Following the 2011 SMS, the Australian Federal Government announced that a new detention centre would be built adjacent to the Channel Island Spur at approximately KP1504.5. This facility is 80 metres away from the pipeline at its closest point, and was expected to accommodate up to 1500 detainees. With a measurement length of this pipeline at 300m, the detention centre resulted in a change in location class. The primary location class was kept at R1, however the secondary location class was changed to S – Sensitive Use. This means that the pipeline is effectively assessed as T2 – High Density. Weekly patrols are performed in this area.

Some sections may be patrolled more frequently than needed due to past activity and a higher risk of encroachment.

7.2 Third party activities

Threats to the pipeline from third parties are controlled and monitored through:

- The Dial Before You Dig (DBYD) system
- Landowner liaison
- Aerial Patrols
- Easement audits

All vehicles over 8 Tonne are assessed by Engineering to determine their suitability to cross the pipeline. If necessary, additional cover will be added to the pipeline, or an alternative crossing location will be identified.

There has been several instances of graffiti / intentional damage to exposed pipework beneath the Channel Island and Elizabeth River bridges. In one instance, paint was deliberately scratched off from the pipe surface. Such damage has been removed. Annual inspections are performed in these areas.

7.3 Review of Incident Reports

All incidents that take place on these pipelines are reported to the APA Group management team.

8 Strategy for Unpiggable Pipelines

Refer to Table 9 below for a summary of whether each relevant pipeline section can be pigged.

Table 9. Summary of whether pipelines are piggable

Pipeline Licence	Pipeline	Section Start	Section End	Piggable?	Reason
PL004	AGP	PVL	TMR	Yes	
		TMR	TTR	Yes	
		TTR	WCH	Yes	
		WCH	WAR	Yes	

Pipeline Licence	Pipeline	Section Start	Section End	Piggable?	Reason
		WAR	RNS	Yes	
		RNS	NCW	Yes	
		NCW	DLW	Yes	
		DLW	MAT	Yes	
		MAT	HEL	Yes	
		HEL	BBS	Yes	
		BBS	DCG	Yes	
		DCG	CIMS	No	Refer to note 1.
		MER	TYP	Yes	
		KTO	KMS	No	Flows are too low to perform intelligent pigging on this 4” lateral. Refer to note 2.
		TCO	TMS	No	Flows are too low to perform intelligent pigging on this 4” lateral. Refer to note 2.
PL010	Elliot Lateral	ELO	EMS	No	Flows are too low to perform intelligent pigging on this 3” lateral. Refer to note 2.
PL018	Darwin Distribution System	DCG	Berrimah Road	No	Flows are too low to perform intelligent pigging on this 6” lateral. Refer to note 2.
PL019	Mt Todd Lateral	MTO	MTD	No	Flows are too low to perform intelligent pigging on this 8” lateral. Refer to note 2.

Notes:

1. The section between Darwin City Gate and Channel Island has never been pigged due to the change in pipe diameter from 12” to 8” across the Channel Island bridge. A project is underway to replace this section to make it piggable. Expected completion of this project is 2017. Without being able to pig, DCVG surveys are conducted annually, and all defects greater than 1%IR are inspected. During these digups in 2011, a girth weld was inspected adjacent to each coating defect to check the integrity of the girth weld sleeves. These inspections did not detect any significant corrosion. The pipe in the 12” section of the entire lateral is heavy wall (7.92mm wall thickness).
2. The short small diameter laterals of the Amadeus Pipeline, the Darwin to Berrimah Pipeline or the Mt Todd pipeline have never been pigged. This is due to the small diameter plus extremely low flows. All laterals have a 5-year DCVG inspection frequency. APA Group will consider new technologies if they are able to assist pigging of low flow, small diameter pipelines.

9 Asset Integrity Programs

Activity	Frequency	Driver	Last	Next	Compliant	Comment
In-line Activities						
MFL Inspection	10 year	Corrosion Growth	Various	Various	Yes	Refer to Table 5 for recent pigging history.
Geometry Inspection	n/a	National APA Policy	n/a	n/a		MFL inspections will indicate the presence of potential dents. If there are a few minor dents, these will be excavated and inspected. If there is a significant number, a geometry inspection may be performed. Some ILI vendors have a tool in which dent data is captured, but only processed in the event that dents are detected.
Crack Detection	n/a	n/a	n/a	n/a	n/a	SCC is assessed to be a low risk for these pipelines.
XYZ	On change	National APA Group ILI Policy	Various	Various	Yes	XYZ data (GPS coordinates of features) was obtained for the first time in 2009 for NT pipelines. All future inspections that have not previously had an XYZ inspection should have this incorporated with the MFL where possible. Refer to the APA Group ILI Policy.
Cleaning	10 year	Vendor	Various	Various	Yes	Cleaning will typically occur prior to MFL inspection
Gauging	10 year	Vendor	Various	Various	Yes	Gauge pigs have typically been run prior to MFL inspection. Gauge pigs may be run in the Wauchope to Warrego section, in the event of a significant earth tremor near Tennant Creek.
Other-Specify						
Direct Assessment / Excavation Programs						
SCCDA - Longitudinal Cracking	n/a					

Activity	Frequency	Driver	Last	Next	Compliant	Comment
SCCDA - Circumferential Cracking	n/a					
Corrosion DA	n/a					Direct assessments perfomed from IP data. No specific DA program
Unpiggable Pipelines	Various					Refer to section 8 for more details on unpiggable pipelines
ILI Validation/Urgent Repair	See comment		Various			As per ILI inspection frequencies.
ILI Growth Repair	See comment		Various			As per ILI inspection frequencies.
Coating Defect Repair	See comment		Various			Coating surveys are only going to be performed on un-piggable pipelines. Refer to section 6.4.2 and section 8.
MPI Inspection when pipe exposed	See comment		Various			MPI testing will be performed during all inspections where the operator is suitably trained.
Buried Station Pipework	See comment		Some stations in 2012	2014		Refer to section 6.4.3 for more details on buried station pipework.
Above Ground Station Pipework	Annual					
Other-Specify						
Emergency Response Management						
ER Exercise	2 years		2014	2016		
Emergency Services Liaison						
Other-Specify						

10 Routine Maintenance Activities - All Pipelines

Table 6.1: Integrity Activities – all pipelines

Activity	Frequency	Driver	Comments (Supporting documentation/reference, Reasons for Activity not carried out on this Pipeline Segment)
Corrosion Control Activities			
Test Point Potential Survey On/Off	Annual	AS 2832.3	Refer to annual CP reports
Test Point Potential Survey On	Annual	AS 2832.3	Refer to annual CP reports
Test Point Potential Survey - Logged	Annual	AS 2832.3	Refer to annual CP reports
CP Unit Operational Check (includes station pipe potential)	2 months plus continuous SCADA monitoring.	AS 2832.3	
Corrosion Coupon Monitoring	2 months	AS 2832.3	
Surge Diverter	Annual	AS 2832.3	
Insulation Joint Check	2 months	AS 2832.3	
Scraper/Compressor Station CP Survey		AS 2832.3	Refer to annual CP reports
Sacrificial Anode Monitoring	Annual	AS 2832.3	Refer to annual CP reports
Interference Testing	Annual	AS 2832.3	Refer to annual CP reports
Ground Bed Watering	n/a		Not performed in the NT
Cased Crossing Isolation Check			No such crossings in the NT
Current Demand Monitoring	2 months plus continuous SCADA		

Activity	Frequency	Driver	Comments (Supporting documentation/reference, Reasons for Activity not carried out on this Pipeline Segment)
	monitoring.		
AC Monitoring	Annual	AS 4853	
Lightning Mitigation	Annual		
AC Mitigation	Annual	AS 4853	
Internal Corrosion Coupon	n/a	n/a	
Other-Specify			
Ground Bed Testing	Annual	AS 2832.3	Refer to annual CP reports
Pipe supports (MLVs and blow down supports)	Annual	AS 2832.3	Refer to annual CP reports
Lands Management Activities			
Pipeline Awareness Liaison	Annual	AS2885.3	
Ground Patrol	Annual	AS2885.3	
Aerial Patrol	1 month	AS2885.3	Monthly aerial patrol reports
Aerial Photography	1 month	AS2885.3	Monthly aerial patrol reports
Satellite Monitoring	n/a	n/a	
DBYD follow up	Various	AS2885.3	All DBYD enquiries followed through as required
Landholder Liaison	Six months	AS2885.3	
Monitoring Development Proposals	Various	AS2885.3	
Depth of Cover Checks	Various	AS2885.3	As required if identified by other patrols (eg aerial patrol) and also where third party activities require a vehicle crossing.
Marker Maintenance	As identified	AS2885.3	As identified by ROW audits or patrol
Vegetation Control	As identified	AS2885.3	As identified by ROW audits or patrol
Ground Movement Monitoring	As identified	AS2885.3	Geoscience Australia website monitored monthly for earthquake activity
Other-Specify			
Pipeline Control Management			

Activity	Frequency	Driver	Comments (Supporting documentation/reference, Reasons for Activity not carried out on this Pipeline Segment)
Gas Quality Monitored for Corrosives/Impurities	Continuous SCADA monitoring. Gas samples tested independently annualy.	Contract	
Pressure Cycles Controlled	n/a		No compression exists on these pipelines. Pressures are continually monitored through SCADA with appropriate alarm setpoints.
Temperature Controlled	Continuous SCADA monitoring.		
Over Pressure System	Continuous SCADA monitoring, PCV overhauls (2 years)		
Leak Detection System	Station checks (annually) Pipeline leaks driven by intelligent pigging		
Other-Specify			
Station Activities			
Site Visual Inspection	2 months	AS2885.3	Some sites inspected more frequently
Minor Valve Service - Mechanical	6 months	AS2885.3	
Minor Valve Service - Electrical and Instrumentation	6 months	AS2885.3	

Activity	Frequency	Driver	**Comments** **(Supporting documentation/reference, Reasons for Activity not carried out on this Pipeline Segment)**
Major Valve Service - Mechanical	Annual	AS2885.3	
Major Valve Service - Electrical and Instrumentation	Annual	AS2885.3	
Scraper Station Service	2 months	AS2885.3	
Pressure Vessel Inspection - Internal	4 years	AS2885.3	
Pressure Vessel Inspection - External	2 years	AS2885.3	
Maintenance Painting	10 years	AS2885.3	As per inspection and as required
Soil/Air Interface Coating Inspection	Annual	AS2885.3	Needs to be added to CMMS
Pipe Support Inspections	2 months	AS2885.3	
Inspection Under Insulation	Annual	AS2885.3	Needs to be added to CMMS
Valve Condition Register	2 years	AS2885.3	In conjunction with valve greasing
Valve Operator Overhaul	5 years	AS2885.3	Some sites performe d more frequently subject to climatic conditions.
Erosion Monitoring (Internal)	2 years	AS2885.3	PCV overhaul
Over-pressure control system maintenance/calibration	Annual / 4 years	AS2885.3	Slamshut protection calibrated annually, PSV 4 yearly
Other-Specify			
Valve Greasing	2 years		
Rotating Plant Activities			
Vibration Monitoring	N/A		No rotating equipment

Activity	Frequency	Driver	Comments (Supporting documentation/reference, Reasons for Activity not carried out on this Pipeline Segment)
Oil Sampling	N/A		No rotating equipment
Thermal Imaging	N/A		No rotating equipment
Overhaul	N/A		No rotating equipment
Maintenance - Mechanical	N/A		No rotating equipment
Maintenance - Electrical	N/A		No rotating equipment
Inspection	N/A		No rotating equipment
Fire System Maintenance	N/A		No rotating equipment
Gas Detection Maintenance	N/A		No rotating equipment
Other-Specify	N/A		No rotating equipment
Over-Line Survey Activities			
DCVG	As required		Only performed on pipeline sections that cannot be pigged.
Pearson Survey	N/A		
Current Mapping	N/A		
CIPS	N/A		
Leak	N/A		
Other-Specify			