WATER NEW ZEALAND
Good Practice Guide

NATIONAL ASBESTOS CEMENT PRESSURE PIPE MANUAL

Volume One

USER GUIDE

Second Edition | February 2017

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Preface

Asbestos cement pipes were an integral part of infrastructure investment in New Zealand until 1986 when manufacture and installation of AC pipes ceased.

Most pipes have now been in service for at least 30 years with the oldest confirmed pipes in service for almost 80 years.

Many AC pipes in NZ have been bedded and backfilled with native soils often containing stones up to 80 mm diameter as this was considered standard practice for many pipelines, especially rural water supply schemes installed during the 1970's and 1980's.

There has been a perception that the steam cured pipes (installed from 1959) deteriorate at a slower rate than the earlier water cured pipes. However Opus experience suggests there is no marked difference in the rate of deterioration.

This updated manual will be of value to consultants and engineering practitioners. It updates the deterioration curves and includes new material on the handling of AC pipes from a health and safety standpoint.

My thanks to the Water Service Managers Group of Water New Zealand funding the updating of this important technical manual.

The first edition of this document was prepared for the Water Supply Managers' Group of the New Zealand Water & Wastes Association and the Ministry of Health by Works Consultancy Services Ltd in 1995. It was subsequently updated in 1997 prior to this edition. This edition was updated with input from ESR, Orica Chemnet, Ministry of Health and Water New Zealand with review by representatives of the Water Service Managers Group.

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Watercare
Water Corp, WA
Wellington Water
Whangarei District Council
Whakatane District Council

2 PURPOSE OF THE MANUAL

This Good Practice Manual has been developed to assist water infrastructure Asset Managers with understanding the condition and likely remaining life of their Asbestos Cement (AC) pressure pipelines.

2.1 New Zealand Metadata Standards

New Zealand Metadata Standards for potable water, wastewater and stormwater provide a *"Global Asset* M*etadata Schemata".* The core asset metadata is divided into 12 sections (X-axis) and 5 volumes (Y-axis) that, in-part, represent the life of a piped asset.

This Good Practice Manual is aligned with Section 2 (red box), and will contribute to Volume 3, inventory methodologies (blue box) and Volume 4, inventory analytics (green box), refer to Figure 2-1.

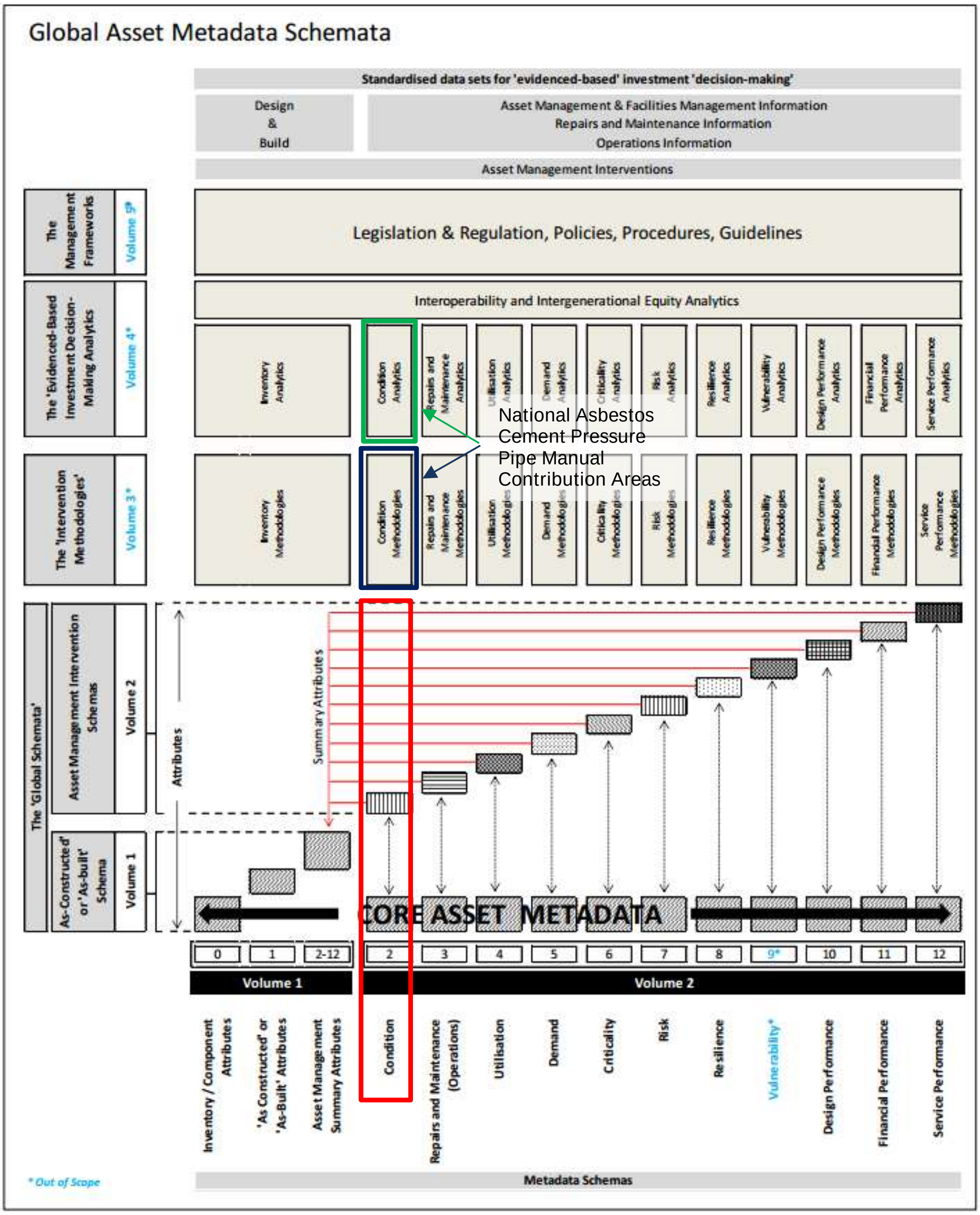

Figure 2-1 Global Asset Metadata Schemata

2.2 Asset Management Process

By following the processes and procedures for determining pipe condition and estimated remaining life that are given in this manual, Asset Managers have a tool to assist with planning for renewal of their AC pipe assets.

2.3 Asbestos Cement Pressure Pipe Condition Assessment

The following processes and procedures will provide the water industry with a consistent and repeatable approach to AC pressure pipe condition assessment.

Three condition assessment approaches (with reducing levels of uncertainty) are covered in this manual:

- Level 1, the desk-top method (for use where no formal condition assessment information is available)
- Level 2, on-site assessment (which can include full condition assessment), and
- Level 3, full condition assessment

Knowledge of the relative condition of AC pipes within a network and the estimated remaining life can be used as inputs for both long-term renewal planning as well as for short-term prioritisation for pipeline replacement.

The Health and Safety section (Section 5) is written to enable Asset Owners, Contractors, Pipe Condition Assessors and other Professionals (the users) better understand potential risks and safe working practices when working with AC pipes.

All Health and Safety and Asbestos Management plans must comply with the latest legislation, regulations, codes of practice and asbestos approved methods.

2.4 Technical & Supporting Data

This volume has been developed as a user guide, however, the technical development and references along with the relevant supporting data is detailed in Volume 2.

Where necessary, cross reference is made to Volume 2, should the user wish to further understand the processes and technical aspects of this Good Practice Manual.

3 USER GUIDES TO THE MANUAL

3.1 Introduction

Prioritised replacement of pipelines (short to long term planning) requires full consideration of all of the risk issues.

It is for the individual Asset Managers to determine the criticality of their pipeline assets and what level of risk is acceptable. This requires detailed understanding of the consequences of failure of each pipeline. At least the following issues need to be considered:

- Disruption to supply (or discharge of effluent in the case of a wastewater pressure main) in the event of a pipe failure. This includes the duration of the disruption, the number and importance of the customers affected.
- Public perception of shut-downs or sewage spillage (includes frequency of events, potential for complaints to local and national political representatives).
- Consequential damage e.g. flooding due to pipe burst.
- Media coverage (local, national and potentially international for major events).
- Traffic disruption (even a small pipeline failing in a major transport corridor can have far reaching consequences).

The condition of AC pipelines can be influenced by many factors, some of which are largely independent of deterioration of the pipe, for example:

- Pipe manufacturing tolerances (pipes had a wide variability in wall thickness).
- The recorded year of installation. Some asset / GIS registers use ‘default’ years when the actual year is not known. Incorrect (default year) values will affect the calculated rate of deterioration if the default year is significantly different from the actual year.
- Handling damage during installation (cracked pipes were sometimes installed).
- The wrong pressure class of pipe was installed.
- Third party interference after installation, e.g. directional drilling, thrusting, failure to restore pipe support after trenching to install an adjacent or deeper service.
- Construction machinery vibration and/or heavy wheel loads.
- Changes in operating conditions (increased pressure, cycling pressures e.g. pump start / stop transients, “hunting” PRV’s, etc.)
- Water quality, both reticulated water or effluent and the groundwater / soil environment.

It should be noted that there is no fool-proof methodology or “silver bullet” for condition assessment and remaining lifetime prediction for pipes of any material. Three levels of condition assessment are outlined below:

3.1.1 Level 1 Condition Assessment – Desk-Top

Where no physical samples or condition assessments have been undertaken, a Level 1 Condition Assessment allows an asset owner to assign a “first-cut” remaining life and condition grade to any pipeline.

This method has a number of limitations and uncertainties as it is based on assumptions and best guesses that are heavily dependent on the reliability of the asset records.

By using this approach, the pipelines that are most at risk of failure due to deterioration can be identified for more formal condition assessment.

3.1.2 Level 2 Condition Assessment – On any Exposed pipe

Level 2 Condition Assessments can be carried out whenever a pipe is exposed.

This approach reduces the number of assumptions and uncertainties associated with a Level 1 Condition Assessment. For example, the pipe diameter, exterior condition, exterior deterioration depth and peak operating pressure can be directly determined and sometimes year of manufacture and pressure class is visible on the pipe or joint collar.

The elimination of many of the assumptions made in a level 1 assessment reduces the uncertainties and the likelihood of unexpected failure. The results of a level 2 assessment can be used in the deterioration model to predict remaining life. However, there is uncertainty regarding the pipe wall thickness and interior deterioration depth.

3.1.3 Level 3 – Full Condition Assessment

Level 3 Condition Assessments allow a detailed condition assessment to be carried out for pipe or core samples. A level 3 condition assessment can be carried out on site by suitably experienced operatives on a recovered pipe or core sample. More detailed information on pipe flaws, de-lamination and deterioration depth can be obtained by the use of CT scanning but this requires another level of expertise and safe off-site handling of the pipe or core samples.

This method provides the most reliable condition results as all of the key condition parameters (pipe diameter, pressure class, wall thickness, deterioration depth, peak operating pressure and pressure transients) are known.

The results of a level 3 condition assessment are used in the Lifetime Prediction Model and this method gives the highest level of certainty

3.2 User Guide to Level 1 Condition Assessment – Desk-Top

Where no physical pipe sampling and condition assessments have been carried out, the Lifetime Prediction Charts (refer to Section 6, Volume 2) are intended to give Asset Managers a desk-top condition assessment and estimate of the likely remaining life of the AC pressure pipes.

Figure 3-1 gives a step by step guide for a desk-top condition assessment.

USER GUIDE TO LEVEL 1 CONDITION ASSESMENT: DESK-TOP

Desk-Top Assessment Method
No Physical Sample Assessed

STEP 1
Select pipe diameter and pressure class (either from GIS System or Table 3-1 [pipe class only])

STEP 2
Select year installed and peak operating pressure

STEP 3
Allocate a confidence rating between low and high to the pipe data

STEP 4
Select pipe purpose (water, wastewater or stormwater) and the appropriate lifetime prediction chart from Volume 2, Section 5

STEP 5
Plot the peak operating pressure on the horizontal axis, where it crosses with the relevant pressure class band, read-off the predicted years to failure on the horizontal axis

STEP 6
Select the appropriate condition grading charge from Volume 2, Section 6

NOTE
The level of confidence for this method is the lowest of all three condition assessment levels, as it is reliant on the quality and accuracy of asset data records and / or the GIS System and any assumptions made

STEP 7
Plot both the remaining life (in years) on the horizontal axis and peak operating pressure on the vertical axis, where the two lines intersect, read-off the condition grade

Figure 3-1 Level 1 Condition Assessment Process – Desk Top

3.2.1 Limitations and Uncertainties of the Desk-Top Method

This assessment procedure is heavily dependent on the reliability of asset data records or GIS systems. Some GIS systems and asset registers do not record the pipe pressure class.

The lifetime prediction band for each pipe class is based on the following criteria:

- Minimum allowable wall thickness in the manufacturing standard and surge factor of 1.5 (this gives the shortest predicted lifetime profile).
- Maximum allowable wall thickness in the manufacturing standard and surge factor of 1.1 (this gives the longest or greatest predicted lifetime profile).
- NZ national average pipe deterioration rate (which could result in under or over estimating the predicted lifetime).

When the Asset owner has a high level of confidence in their data, the upper reaches of the lifetime prediction band may be used. Conversely, if confidence in the data is low the lower reaches of the lifetime prediction band should be used.

However, the relationship between peak operating pressure, pipe pressure class and years to failure as found from the charts is fairly reliable.

Section 5 of Volume 2, details the key data required, fixed values, the charts limitations and use.

Figure 3-2 shows an example of a DN 150 AC watermain, a peak operating pressure of 80 m head, and assumed to be Class C. The lifetime prediction range is approximately 41 – 58 years from year of installation (green arrows on the chart). However, if the pipe is actually Class AB, the lifetime prediction range would be reduced to approximately 25 – 39 years from installation year (red arrows on chart). Conversely, if the pipe is Class D, the lifetime prediction range would be 51 – 68 years from year of installation.

This example highlights the importance of the pipe pressure class in lifetime predictions. As a consequence of the assumptions, Level 1 Condition Assessments have a higher level of uncertainty than Level 2 and 3 Condition Assessments.

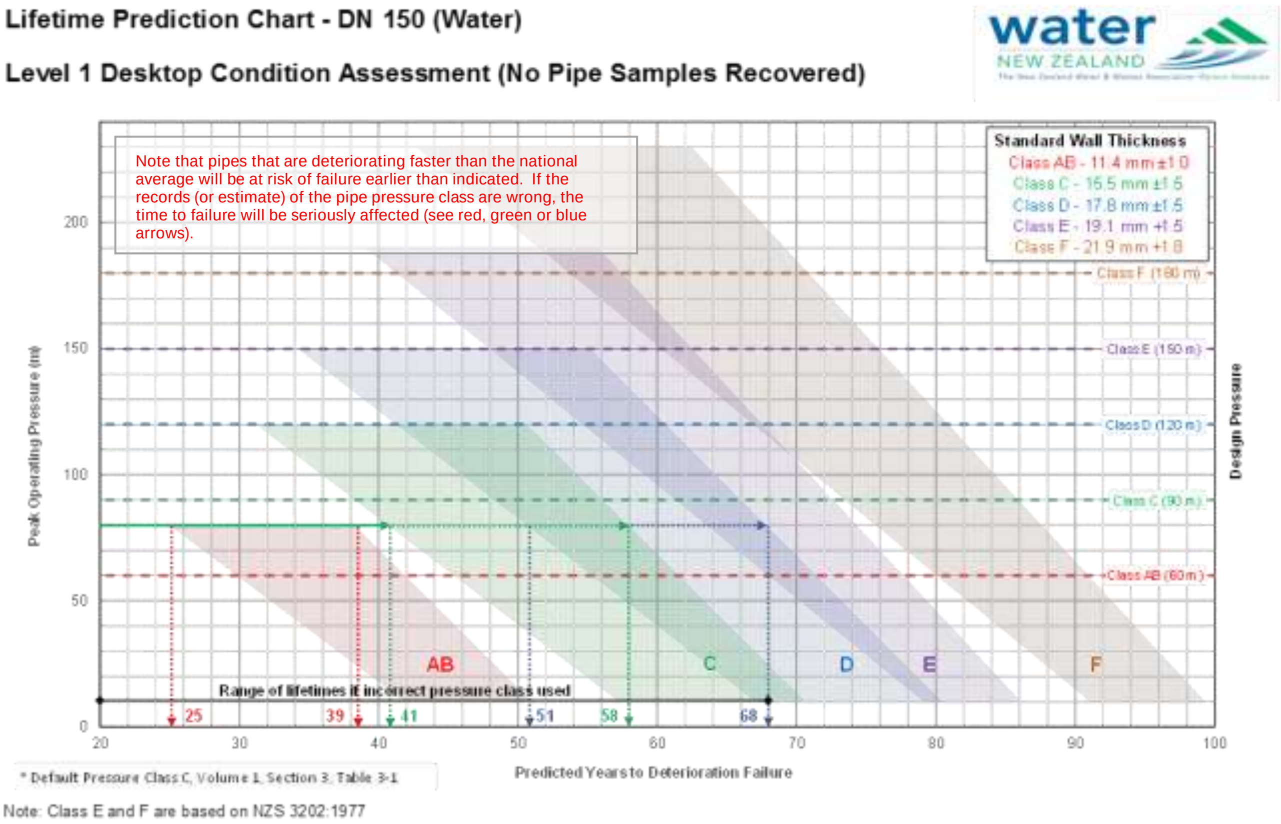

Figure 3-2 Likelihood of Failure

3.2.2 Using the Lifetime Prediction Charts for Desk-Top Condition Assessment

When using the Lifetime Prediction Charts, the following information is necessary:

- Pipe purpose (water, wastewater or stormwater).
- Installation year (from GIS or other records).
- Pipe diameter (from GIS or if unknown, best estimate).
- Peak operating pressure (estimate from reservoir level minus pipeline level or pressure gauge reading, m head of water).
- Pipe pressure class (from GIS, local knowledge or default value from Table 3-1).

Select the appropriate Lifetime Prediction Chart for the chosen pipe diameter, pressure class and pipe purpose to determine the predicted number of years to first failure due to deterioration.

Referring to Figure 3-2, if the pipeline was installed in 1970 and a Level 1 Condition Assessment was carried out in 2016, a Class C pipe estimated lifetime range would range between 2011 (1970 + 41 years) and 2028 (1970 + 58 years).

3.2.3 Range of the Predicted Lifetimes

Provided that the pipe diameter, assumed pressure class, and peak operating pressure is correct, and the deterioration rate is similar to the national average, the upper lifetime prediction value can be used and the likelihood of deterioration failures occurring before 2028 is low.
However, the number of assumptions increases the level of uncertainty associated with this method and the lower lifetime prediction value should be used.

For example, if the peak operating pressure and pipe class are known (high confidence), but the deterioration rate and wall thickness is unknown (low confidence). The overall confidence allocated to the pipe data is classed moderate / adequate and the predicted years to deterioration failure is estimated at ≈ mid-way between the lower and higher, refer to Figure 3-3.

Figure 3-3 illustrates a range of 17 years for a DN 150 (Water) Class C AC pressure pipe, peak operating pressure of 80 m head.

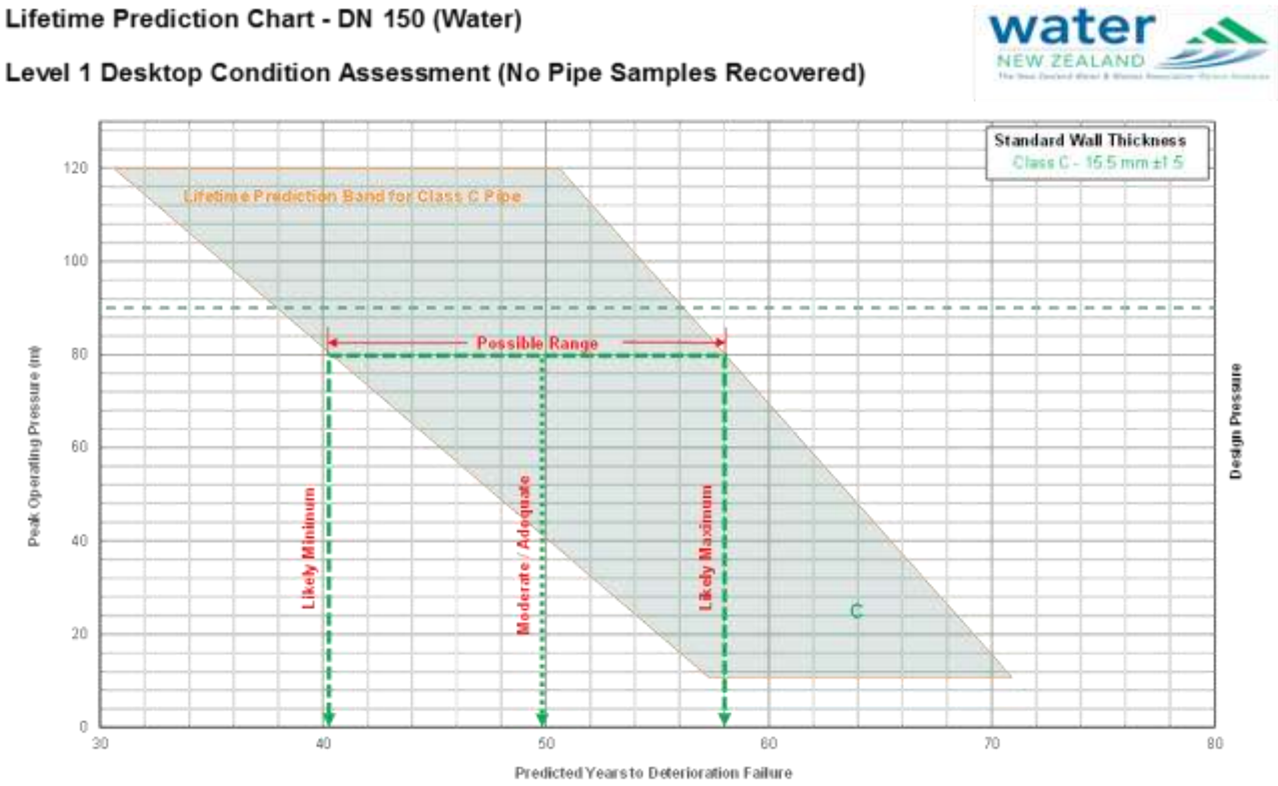

Figure 3-3 of the Predicted Lifetime Range for a DN 150 (Water) Class C Pipe

3.2.4 User Guide to Typical or Likely Pipe Pressure Class

If a pipe or core sample has not been recovered and the pipe pressure class is not recorded in the pipe asset data, the default pressure classes presented in Table 3-1 may be used.
The default pressure classes are based on the most common pressure class assessed for each diameter over the last 10 or more years as well as many water authorities' policies.

Table 3-1 – Default Pressure Classes for all Pipe Sizes

Pipe Diameter (DN)	Default Pressure Class	Pipe Diameter (DN)	Default Pressure Class
50	AF	250	C
75 / 80	CD	300	C
100	CD	375	C
150	C	450	B
200	C	525	B
225	C	600	B

3.2.5 User Guide to the Condition Grading Charts

Using the example in Section 3.2.2, the lifetime prediction range is 2011 to 2028, the maximum likely remaining life to failure is 12 years (2028-2016).

By plotting the remaining life range and the peak operating pressure on the appropriate condition grading chart, the intersection points give the Condition Grade. In this example the condition grade is 4 (poor), see Figure 3-4.

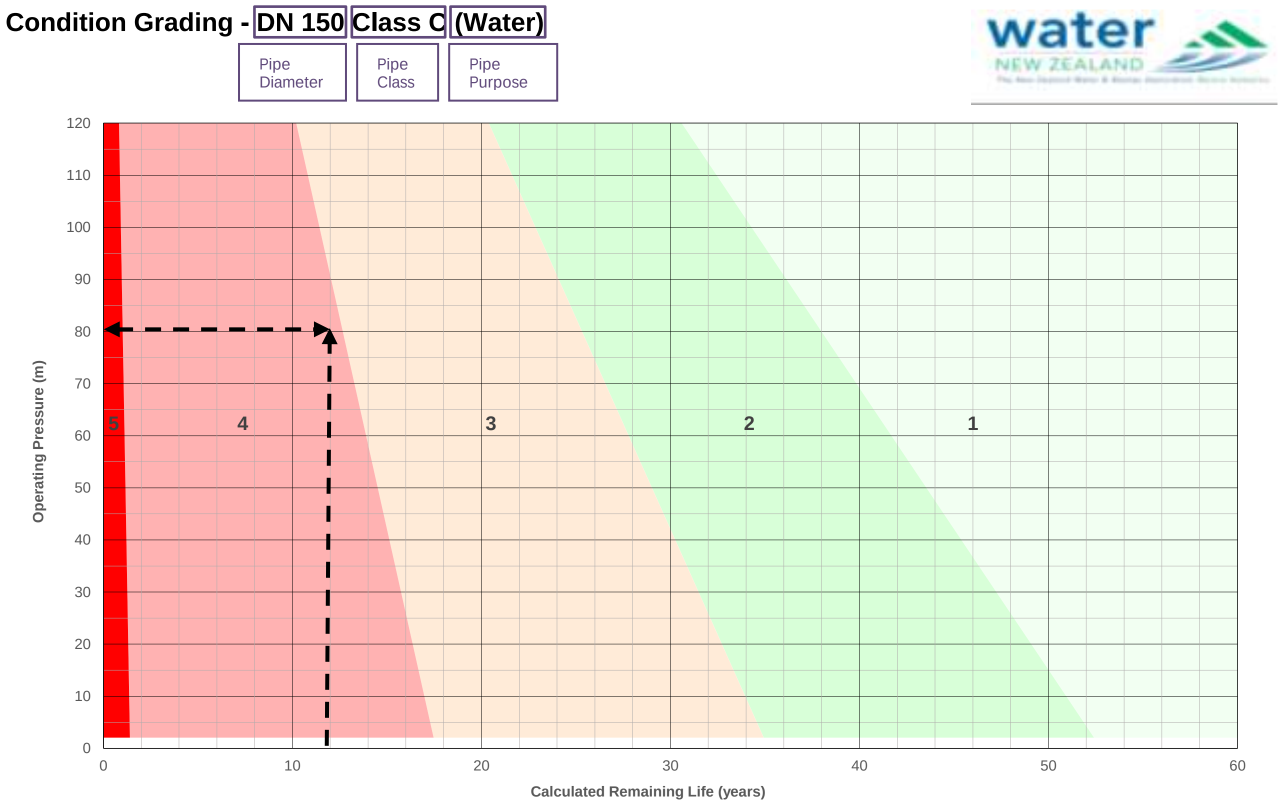

Figure 3-4 Condition Grading Chart

Section 6 of Volume 2 defines the meaning of each condition grade, and how to use the grading charts.

3.3 User Guide to Level 2 Condition Assessment – On-Site Exposed Pipe

Figure 3-5 gives a step by step guide for a condition assessment carried out in situ on any exposed pipe. The data that is gained can be used in the deterioration model.

USER GUIDE TO LEVEL 2 CONDITION ASSESMENT: ON-SITE EXPOSED PIPE

In-Situ Assessment Method

STEP 1
Completely expose pipe

STEP 2
Carefully clean the pipe exterior and look for any identifying markings, take photos

STEP 3
Accurately measure (using a π tape) the pipe OD (to ±0.5 mm or better) and record

STEP 4
Determine exterior deterioration depth by notching & phenolphthalein or penetration depth and record

STEP 5
If a pipe or core sample is not recovered, the pipe class & internal deterioration depth will be unknown. Use the pressure class from GIS or asset records or use default pipe class from (Table 3-1)

STEP 6
Use the national average internal deterioration rate from the manual or from other similar samples (if available)

NOTE
The level of confidence for this method can be significantly lower than that for the pipe or core sampling method but is better than the desk-top method

STEP 7
Input the site measured OD & exterior deterioration information, the wall thickness for the assumed pipe pressure class and the estimated internal deterioration depth in to the Working Database & Lifetime Prediction Model to predict the year to the first failure

Figure 3-5 Level 2 Condition Assessment Process – On-Site Exposed Pipe

Section 3 of Volume 2 provides details regarding AC pipe condition assessment, Section 3.4 specifically refers to in-situ condition assessment.

3.4 User Guide to Level 3 – Full Condition Assessment

Figure 3-6 gives a step by step guide for full condition assessment that can be carried out on-site or off-site in a safe handling facility (SHF).

This process provides the essential data (OD, ID, Wall thickness, external and internal deterioration depths and pipe pressure class) used in the deterioration model[1].

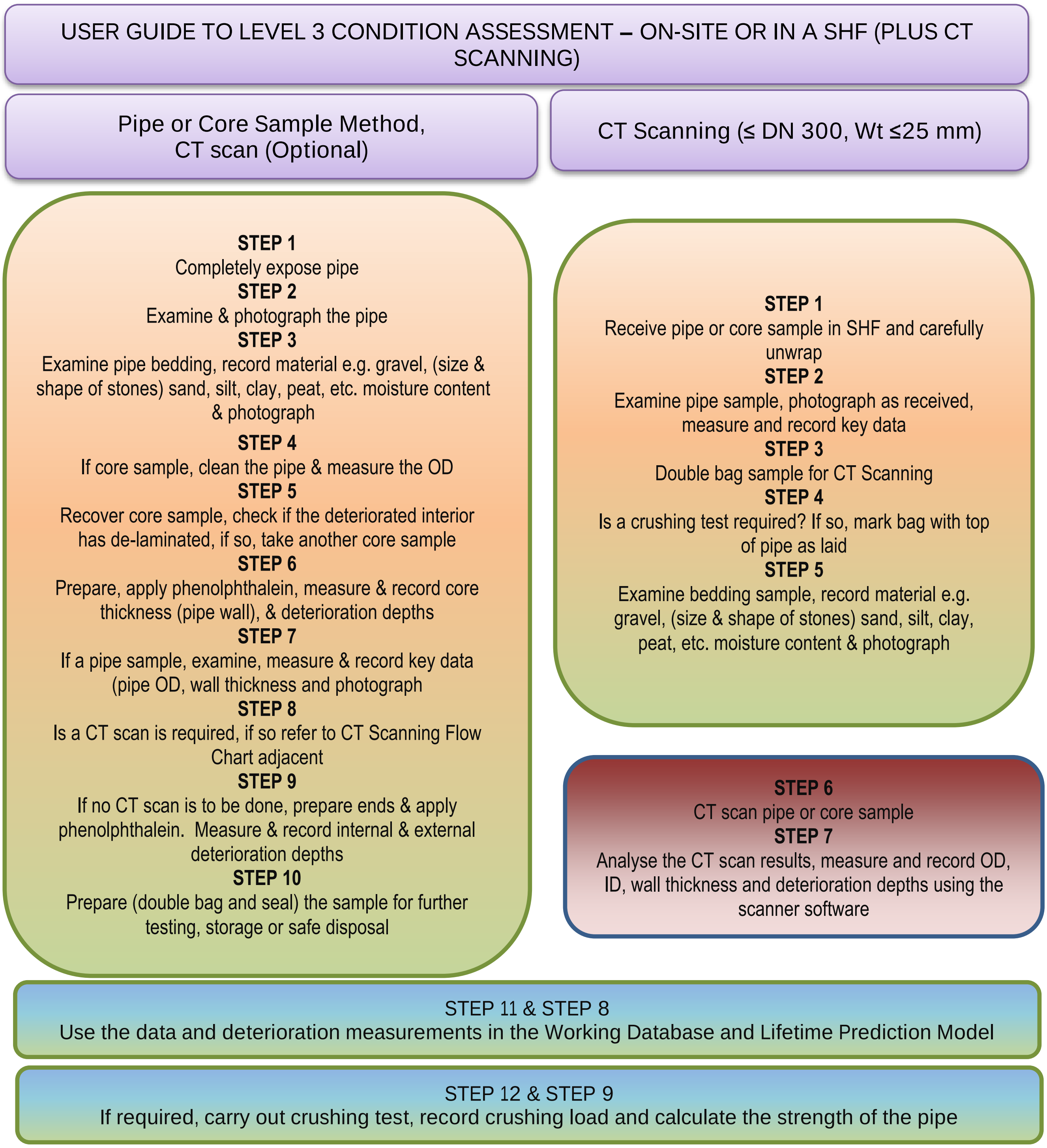

Figure 3-6 Level 3 Condition Assessment Process – Full Condition Assessment

Section 3 of Volume 2 provides details regarding the condition assessment of AC pipes, Section 3.8 specifically refers to and details the various condition assessment techniques for recovered pipe or core samples (whether assessed on-site or in a SHF).

[1] *CT Scanning and crushing tests, use, benefits and when to undertake these tests is explained in Sections 3.8.2 and 3.8.3 of Volume 2.*

3.5 Using the Database and Lifetime Prediction Model

The working database and Lifetime Prediction Model allows the user to enter new condition assessment results and generate remaining lifetime predictions. This is done in two steps:

Step 1: Open the worksheet and check the working version http://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=2032

Step 2: Enter new condition assessment results in the worksheet (red box Figure 3-7) in one of the blank rows. Six example (three water and three wastewater) entries are shown to assist the user.

					Data Required for Deterioration Modelling						
Sample #	DN	Class	Use	Location / Address / Notes	Year Installed	Year Recovered	Operating Pressure (m)	Mean Pipe OD (mm)	Min Wall Thickness (mm)	Max. Ext Det'n	Max. Int Det'n
Example 1	100	CD	Water	Site 1	1958	2016	65.0	126.0	14.7	2.9	8.2
Example 2	150	C	Water	Site 2	1984	2016	42.0	179.7	15.8	3.7	4.8
Example 3	200	C	Water	Site 3	1963	2016	61.0	234.5	19.6	4.3	7.2
Example 4	100	D	Wastewater	Site 4	1954	2016	15.0	130.1	20.1	6.2	11.3
Example 5	225	B	Wastewater	Site 5	1962	2016	6.0	262.8	16.5	3.5	6.4
Example 6	375	B	Wastewater	Site 6	1987	2016	50.0	417.4	23.5	4.1	5.7

Figure 3-7 Enter New Condition Assessment Results in Working Database and Lifetime Prediction Model

The "Variables" section of the worksheet will be automatically populated (red box Figure 3-8) based on the condition assessment data entered. An alternative value for the surge factor can be entered manually at the user's discretion.

The "Results" fields' automatically calculated (yellow box) are:

- The pipe or core samples deterioration rate (mm / yr).
- The comparison of the pipe or core sample deterioration rate with the national average deterioration rate (% faster or slower).
- Estimated remaining pipe lifetime (years).
- Estimated year of first pressure failure due to deterioration.

Data Required for Deterioration Modelling							Variables			Results			
Year Installed	Year Recovered	Operating Pressure (m)	Mean Pipe OD (mm)	Min Wall Thickness (mm)	Max. Ext Det'n	Max. Int Det'n	MPa	Surge Factor	National Det'n Rate	Sample Det'n Rate	Comparison to Nat. Avg.	Estimate Pipe Life	Est. Year of First Det'n Failure
1958	2016	65.0	126.0	14.7	2.9	8.2	15.5	1.5	0.2344	0.1914	18% Slower	57	2015
1984	2016	42.0	179.7	15.8	3.7	4.8	23.5	1.5	0.2344	0.2656	13% Faster	51	2035
1963	2016	61.0	234.5	19.6	4.3	7.2	22.1	1.5	0.2344	0.2170	7% Slower	69	2032
1954	2016	15.0	130.1	20.1	6.2	11.3	15.5	1.5	0.3462	0.2823	18% Slower	68	2022
1962	2016	6.0	262.8	16.5	3.5	6.4	22.1	1.5	0.3462	0.1833	47% Slower	87	2049
1987	2016	50.0	417.4	23.5	4.1	5.7	23.5	1.5	0.3462	0.3379	2% Slower	51	2038

Figure 3-8 Variables & Results Generated by the Working Database and Lifetime Prediction Model

To enter additional appraisal results use additional rows or simply overwrite the results entered in step 1.

Section 4 of Volume 2 details the key data required and fixed values used in the lifetime prediction model.

3.6 User Guide to Working with Asbestos: Working Practice Check List

An example of a working practice check list for recovery of (or in-situ examination of) AC pipe samples is presented in Table 3-2.
All working practices must be compliant with current regulations, legislation, approved codes of practice and asbestos approved methods, refer to Section 5.4.

Table 3-2 – Example of a Working Practice Check List

Working with Asbestos - Working Practice Check List	
Planning (Section 5.3)	❑ Pipe material is believed to contain Asbestos fibres (all AC pipes will). ❑ A suitable and accessible safe disposal facility OR safe temporary storage facility is available. ❑ Engage a suitably qualified Contractor. ❑ Identify suitable decontamination and safe working areas.
Contractor's Training, Competency, Wellbeing (Section 5.5)	A suitably qualified Contractor to work with AC pipes must have: ❑ Experience with obtaining Consents, Road Opening Notices etc. ❑ A current track record. ❑ An appropriate Health and Safety plan. ❑ Asbestos awareness. ❑ Working with and handling AC pipes. ❑ Experience & knowledge demonstrated. ❑ Skills and qualifications. ❑ Annual refresher training. ❑ Fitness and wellbeing for employees using Respiratory Protective Equipment (RPE). Appropriate training, competency and wellbeing attributes demonstrates the Contractor and employees are able to carry out a particular task under the act and regulations in a safe manner.
PPE (Section 5.6)	❑ Disposable overalls / coveralls (with hood and elastic cuffs). ❑ P3 Asbestos RPE. ❑ Safety footwear, rubber (washable) boots with no laces or disposable covers for laced footwear. ❑ Eye protection (where required). ❑ Ear muffs (where required). ❑ Disposable gloves. ❑ Hardhat (if on site).
Controlled Equipment for Working on or with AC pipe (Section 5.8)	❑ Appropriate (Controlled) cutting tools (as necessary): o Hand Saw. o Chain Cutters. o Petrol Powered Cut-Off Saw. o Under Pressure Coring Tool. ❑ Water Supply: o Bucket of water. o Pressure Sprayer. o Garden hose. ❑ Disposable cleaning rags. ❑ Duct or packaging tape. ❑ Substance to isolate dust (e.g. wallpaper paste, shaving foam, hair gel). ❑ 120 µm plastic bags or sheet. ❑ A suitable asbestos waste container (e.g. 120 µm plastic bags or a drum, bin or skip lined with 120 µm plastic sheet). ❑ Warning signs and barrier tape. ❑ A vacuum cleaner with an asbestos rated filter (optional).
Equipment (other)	❑ Appropriate plant and equipment on site. ❑ Suitable pipe and fittings on site to enable work to be carried out. ❑ Site securely barricaded. ❑ Temporary traffic management for vehicles and pedestrians.

Working with Asbestos - Working Practice Check List, **Cont'd**	
Decontamination area	❑ Suitable decontamination area set up. ❑ Sufficient decontamination equipment (e.g. buckets of water and wipes etc.) ❑ Safe disposal procedure established for contaminated material and PPE.
Control of contamination of asbestos work area & equipment	❑ Use damp rags or wipes to clean the tools and equipment. ❑ Carefully roll or fold plastic sheeting to cover surfaces within the asbestos work area, so as not to spill any collected dust or debris. ❑ If necessary, use damp rags or an asbestos vacuum cleaner to clean visibly contaminated sections of the asbestos work area. ❑ Place debris, used rags, plastic sheeting and other waste in asbestos waste bags or a suitable container. ❑ Wet-wipe the external surfaces of the asbestos waste bags/container to remove any adhering dust before removing them from the asbestos work area.
Carry out personal decontamination in designated area	❑ While still wearing RPE, remove disposable PPE (e.g. overalls etc.). Note: overalls turn inside out to trap any remaining contamination and then place them into a labelled asbestos waste bag and seal it. ❑ Remove RPE and dispose of particulate filters (take care not to dislodge dust trapped in the filter). ❑ Wash RPE (minus the filters) with clean water or wipes and dry with paper towels and return to its clean storage container. ❑ If a disposable mask used, place in a labelled asbestos waste bag. ❑ Dis-establish decontamination area and dispose of any contaminated waste in a labelled asbestos waste bag and seal it (or use an appropriate sealable waste container.
Site clearance, final disestablishment	❑ Visually inspect the site to identify any contaminated areas and clean up. ❑ Assume all waste is contaminated with asbestos and dispose of in a safe manner.

Sections 3.1 to 3.6 of Volume 2, provides guidance regarding site preparation and excavation, recovery of pipe and core samples, handling, temporary storage and transportation.

3.7 User Guide to Pipe, Core Sample & In-Situ Test Measurements

User guides aimed at achieving consistency of assessment techniques (Section 3.8 of Volume 2).

Table 3-3 shows the essential measurements to be recorded for use in the deterioration modelling and condition assessment.

Table 3-3 – Recommended Minimum Number of Measurements

Measurement Descriptions (All Pipe Diameters)	Number of Measurements		
	Pipe Sample	Core Sample	On-Site Testing
Pipe OD (by π tape)	1	1	1
Pipe ID	2	1 *(ID inferred from OD – 2x wall thickness)*	Not Applicable if core sample not taken
Wall Thickness *(Make sure that maximum and minimum are included)*	6	2	
Length	1	N/A	
Core Sample Diameter	N/A	1	
Internal Deterioration Depth *(Phenolphthalein and / or CT Scanning)*	6	2 *(check if core has de-laminated)*	
External Deterioration Depths *(Phenolphthalein and / or CT Scanning)*	6	2	Minimum 4 *(Notches or penetrations @ top, bottom & sides)*

3.8 User Guide to Photographic Records

As part of any pipe condition assessment, photographic records are useful. Table 3-4 shows the recommended photographs.

Table 3-4 – Recommended Photographs

Photograph Description	On-Site Assessment	Safe Handling Facility
Over-view of site pre-excavation	✓	
Pipe with pre-cut marking in trench	✓	
Trench walls	✓	
Bedding material and any voids under the pipe	✓	✓ *(if provided with pipe or core sample)*
Manufacturers markings on pipe or collars	✓	✓
Joint Type (if visible / recovered)	✓	✓
Surface damage, scores, gouges etc.	✓	✓
Under pressure tapping set up	✓	
Notch / penetration tests	✓	
Phenolphthalein results	✓	✓
Completed pipe sample recovery report form	✓	
Repaired pipe after sample recovery	✓	

Section 3.2 of Volume 2, provides details of on-site observations and recording of data.

4 CONDITION ASSESSMENT PROGRAMME

A well planned AC pressure pipe condition assessment programme will provide asset owners with an understanding of the condition of their AC water supply, wastewater or stormwater pressure pipes.

A proactive pipe condition assessment programme is likely to be heavily influenced by various key considerations that will vary with asset purpose as well as from asset owner to asset owner.

When planning an AC pressure pipe condition assessment programme, good practice includes understanding:

- The key considerations for selecting pipe sample recovery locations.
- Pipe sample recovery.
- The value of opportunistic pipe sample recovery.

These good practices are detailed below.

4.1 Key Considerations

Key considerations for the development of a pipe condition assessment programme are:

- The percentage / length of AC pipelines in network.
- Pipelines with a burst history.
- Is the pipeline a lifeline or trunk main?
- Pipe location (e.g. depth of cover, topography, surface type and imposed loads etc.).
- Peak operating pressure and possible transients
- The pipeline criticality.
- The consequence of failure.

4.2 Pipe Condition Assessment Planning

- Sort AC pipe assets into cohorts of similar diameter and age with lengths of pipeline.
- Develop a pipe condition assessment programme (incl. recommended level of assessment) and budget aimed at covering at least the most vulnerable pipelines.
- Allow for unforeseen pipe sample assessment (say 10 % of the annual pipe sampling and assessment costs).

4.3 Opportunistic Pipe Condition Assessment

Typically, the physical works associated with exposing or the recovery of pipe samples is the most expensive part of pipe condition assessment.

Opportunistic condition assessments can be carried out on site whenever a pipe is exposed and a pipe sample can be recovered for off-site assessment at minimal additional cost.

Opportunistic on-site assessments and pipe sample recovery can be done as a result of:

- Planned work, e.g. installation of; new connections, fire hydrants, sluice valves, water meters, air release valves, etc.
- Routine maintenance or emergency repairs, e.g. pipe bursts[2], third party damage, etc.

The asset owner may consider developing a pipe condition assessment programme in conjunction with the operations and maintenance contractor so that pipelines or sections of the network that have been targeted for pipe condition assessment (including the level of assessment) are known to the contractor.

[2] Condition assessment on a pipe sample recovered from a burst, may present a worst case scenario (i.e. failure due to deterioration), alternatively it could be a result of significant pressure surge (e.g. rapid closing of a valve) or third party damage. If the likely / probable nature and perceived cause of failure can be identified, it should be recorded.

5 HEALTH AND SAFETY

5.1 Introduction

This Health and Safety section is written to assist and enable Asset Owners, Contractors, Pipe Condition Assessors and other Professionals (the users) to better understand the potential risks when working on or near AC pipes.

This section is not a methodology for the preparation of Health and Safety or Asbestos Management Plans. The users are still required to consider, fully evaluate and verify all actual conditions (for on-site and off-site works) involving AC pipes.

Contractors being engaged to undertake work on the Asset Owners AC pipelines, will need to demonstrate that they have suitable Health and Safety and Asbestos Management Plans in place, prior to being awarded the works.

This document only comments on AC pipes which are located in road corridors, public open spaces, private land (e.g. fields), and safe handling facilities. This document does not consider AC pipes which are located within buildings and structures.

5.2 Asbestos – Why it's a Hazard and Health and Safety Issue

AC pipes are composed of a mixture of Portland cement, asbestos fibres and finely ground silica[3].

Asbestos fibres are hazardous to health and there has been a well-established link between airborne asbestos fibres and asbestosis since before 1900. Two forms of cancer are also associated with the inhalation of asbestos fibres, lung cancer and mesothelioma[4].

Particles of asbestos fibre that can cause health problems are small enough to be invisible to the naked eye. Lung cancer and mesothelioma associated with airborne asbestos can take 10-20 years or more to develop.

It is therefore critical that exposure to airborne asbestos fibres is, where practical, eliminated or appropriate control measures are put in place to protect those working with AC pipes.

However, there is no evidence to show that asbestos fibres will cause any harm when they are wet and swallowed. The effects of asbestos in the water supply have been studied extensively, and results have not shown an elevated risk of asbestos-related disease[5].

When AC pipes are left undisturbed the risk of asbestos fibres becoming airborne is very low, and while they should still be treated as hazardous material, they present very low risk.

Therefore whenever it is practical, AC pipes should be left undisturbed (whether in service or abandoned).

When work on, or around, AC pipes is necessary, good working practices must be adopted to, where practical, eliminate or alternatively minimise exposure to airborne particles.

5.2.1 Identifying Potential Locations of Asbestos Cement Pipes

The Asset Owner and the Operations and Maintenance Contractor need to be able to identify where AC pipes are potentially located (both in-service and abandoned). This may be by means of GIS or another system readily accessible to Contractors engaged to undertake work on or near AC pipes. Also refer to Management and Removal of Asbestos Approved Code of Practice, Section 7.

[3] *Hardie's Fibrolite Pipe – Technical Information 1976.*
[4] *IARC (International Agency for Research of Cancer)*
[5] *http://ww2.health.wa.gov.au/Articles/A_E/Asbestos-in-drinking-water*

5.3 Health and Safety and Asbestos Management Plans

5.3.1 Health and Safety Plan

A suitable and practical Health and Safety Plan is required for anyone working on or near AC pipes. This includes activities such as inspecting, cutting, recovering, handling, transportation and safe disposal of AC pipes (including recovery of pipe samples for condition assessment).

The Health and Safety plan must address how the health and safety of those working on the AC pipe and those who may be affected by the works involving AC pipe (e.g. the public or other contractors working on site) will be adequately protected.

The Health and Safety plan must:

- Comply with the latest legislation, regulations, codes of practice and asbestos approved methods, refer to Section 5.4. Good working practices must also be applied, refer to Section 5.7 and Section 3 of Volume 2.
- Address the training and competency requirements of those handling the AC pipes, refer Section 5.5.
- Specify the Personal Protective Equipment to be worn, refer Section 5.6.
- Identify the working practices to be adopted (proposed methodology to complete the works), refer Section 5.7 and Section 3 of Volume 2.
- Allow for the removal of any AC pipes from the designated work area (including safe disposed and evidence of this). *Note, where more than 10m^2 of Asbestos Containing Materials (ACM) is likely to be removed, licensed asbestos removal specialists shall be engaged to undertake the work.*
- Detail any controlled equipment to be used for the cutting and removal of sections of pipelines or pipe samples for condition assessment. Section 5.8 identifies some general advantages and disadvantages of the various controlled equipment for working with AC pipe.

5.3.2 Asbestos Management Plan

Where an asset owner or a contractor is engaged (either under an Operations and Maintenance Contract or tendered work), a suitable Asbestos Management Plan (AMP) shall be provided and adhered to.

An extract from Section 13 of the Health and Safety at Work (Asbestos) Regulations 2016 is shown below. This clearly states what information *"must"* be included in an AMP.

(4) An asbestos management plan must include information about the following:
- (a) the identification of asbestos or ACM:
- (b) decisions, and reasons for decisions, about the management of the risk arising from asbestos at the workplace:
- (c) procedures for detailing incidents or emergencies involving asbestos or ACM at the workplace:
- (d) the workers who carry out work involving asbestos, including—
  - (i) information and training that has been and will be provided to the workers:
  - (ii) roles and responsibilities of the workers:
  - (iii) any health monitoring of the workers that has been or will be undertaken.

Extract from Section 13 (4) of the Health and Safety at Work (Asbestos) Regulations 2016

Figure 5-1 provides an asbestos management process for an AMP. This figure has been taken from the Management and Removal of Asbestos Approved Code of Practice, Section 9, Figure 16.

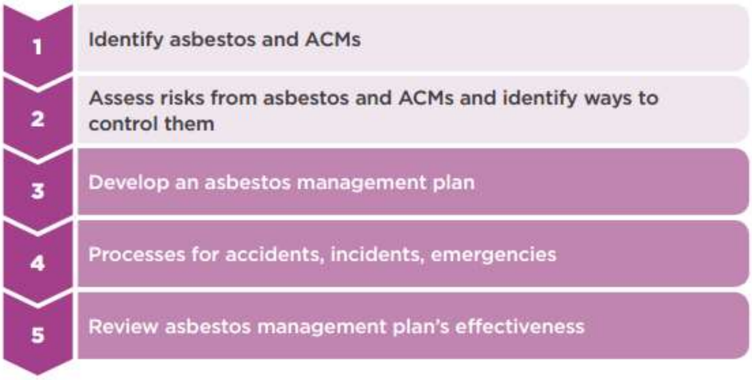

Figure 16: Asbestos management process – asbestos management plans

Figure 5-1 Extract from Section 9 of the Approved Code of Practice for Management and Removal of Asbestos

5.4 Regulations and Legislation Applying to Asbestos

The following regulations, legislation, approved methods of working and approved codes of practice are referenced (including hyperlinks) to allow quick access to the latest documentation.

5.4.1 Health and Safety at Work (Asbestos) Regulations 2016

The Health and Safety at Work (Asbestos) Regulations 2016 (the regulations) contain measures and procedures for work involving and removal of asbestos in a safe manner. The document is free and available from the New Zealand Legislation website:

http://www.legislation.govt.nz/regulation/public/2016/0015/latest/DLM6729706.html

5.4.2 Health and Safety at Work Act 2015

The Health and Safety at Work Act 2015 is also relevant. The document is free and available from the New Zealand Legislation website:

http://www.legislation.govt.nz/act/public/2015/0070/latest/DLM5976660.html

Measures must be taken to minimise asbestos hazards and employees must be adequately trained and deemed competent to work safely with AC pipes. The other requirements of the Act must also be fulfilled.

5.4.3 Management and Removal of Asbestos – Approved Code of Practice

This code of practice provides guidance for complying with both the Health and Safety at Work Act 2015, including the Health and Safety at Work (Asbestos) Regulations 2016. It is free and available from the WorkSafe website:

http://construction.worksafe.govt.nz/assets/guides/asbestos-acop/removal-of-asbestos-acop.pdf

5.4.4 Approved Method for the Transportation and Temporary Storage of Asbestos Containing Materials

An approved method for the transportation and temporary storage of ACMs is currently being prepared by WorkSafe. Once this approved method is signed by WorkSafe's Chief Executive, it is legally effective. All other current asbestos approved methods are free and available from the WorkSafe website:

http://www.worksafe.govt.nz/worksafe/information-guidance/guidance-by-hazard-type/asbestos/working-with-asbestos/asbestos-approved-methods#what.html

Until the approved method is legally effective Asset Owners, Contractors, Pipe Condition Assessors and other Professionals must include their proposed method for the transportation and temporary storage of ACMs.

For good working practice regarding handling, transportation and safe disposal of ACMs refer to Section 3 of Volume 2.

5.4.5 BRANZ Guide to Managing Asbestos in Soil

This guide provides property, business and home owner's step-by-step guidance through the process of managing asbestos in soil. It includes the legal obligations, testing and analysis options, remediation alternatives and guidance on (or advice on) completion of the work to the point where the site can be used for its intended purpose.

The document is free and available from the BRANZ website:

http://www.branz.co.nz/asbestos

5.5 Training and Competency

All employees and contractors who are likely to be working with AC pipes must be appropriately trained and be competent, as required under:

- Health and Safety at Work (Asbestos) Regulations 2016 and;
- The Management and Removal of Asbestos Approved Code of Practice, Section 12.

Broadly, evidence of competency to work with AC pipes for each employee can be demonstrated by:

- Knowledge
- Experience
- Skill
- Training / Qualifications
- Asbestos Removal Licence

5.6 Personal Protective Equipment

It is essential when working on AC pipes that any asbestos fibres are not inhaled and / or transferred from the controlled working area (e.g. fibres attached to safety footwear [laces], hair or clothing) and exposing others to the asbestos fibres.

Personal protective equipment (PPE) must be worn at ALL times when working with AC pipes.

5.6.1 What PPE Must be Worn When Asbestos Is or May Be Present:

WorkSafe New Zealand has provided a detailed information sheet to assist in determining when and what PPE is to be used when working with Asbestos.

The information sheet also explains what the Person's Conducting a Business or Undertaking responsibility is regarding PPE and is free and available for download from the website.

Also refer to Management and Removal of Asbestos Approved Code of Practice, Section 14:

https://www.worksafe.govt.nz/worksafe/information-guidance/all-guidance-items/asbestos-factsheets/personal-protective-equipment-to-use-when-working-with-asbestos/ppe-working-with-asbestos-pdf

5.6.2 Health and Safety Plan for the Use of Controlled Equipment:

When using controlled equipment (Section 5.8), it's important that appropriate PPE is used to protect the health and safety of the workers and the public. The contractor's Health and Safety Plan may require additional PPE for the use and operation of some controlled equipment.

5.7 Safe Working Practices

When working with AC pipes, minimise the time taken to complete the works as much as possible and practicable (without compromising health and safety or the quality and reliability of the work).

Practical steps to be considered include:

- Pre-planning work so that work can be completed quickly and without delays. Ensure all material and equipment is on site to avoid the need to repeatedly remove and safely dispose of disposable clothing (e.g. having to leave site to collect additional items etc.).
- A supply of plastic bags for the safe disposal of disposable PPE items.

A working practice check list may be beneficial in assisting with the whole process (from identifying potential asbestos pipes through to completion of the work). An example of a working practice check list is presented in Section 3.6.

Refer also to Management and Removal of Asbestos Approved Code of Practice, Section 11.

5.8 Controlled Equipment

Take care to avoid generating dust which could become airborne when working on an AC pipeline (e.g. using controlled equipment) for repair work, inspection or recovery of a pipe or core sample for condition assessment.

An extract from Section 18 (4) of the Health and Safety at Work (Asbestos) Regulations 2016 is shown below. This clearly states *"the use of equipment is controlled if…."*

(4) For the purposes of subclause (3), the use of equipment is **controlled** if—

(a) the equipment is enclosed while being used; or

(b) the equipment is designed to capture or suppress airborne asbestos and is used in accordance with its design; or

(c) the equipment is used in a way that is designed to capture or suppress airborne asbestos safely; or

(d) any combination of paragraphs (a), (b), and (c) applies.

Extract from Section 18 (4) of the Health and Safety at Work (Asbestos) Regulations 2016

Table 5-1 to Table 5-4 present the four main methods for cutting AC pipe (tungsten carbide hand saw, hammer and chisel, chain cutters, petrol cut-off saw and under-pressure tapping). The tables identify some general advantages and disadvantages of working with these tools and the user must consider these advantages and disadvantages when selecting the equipment to be used.

These advantages and disadvantages should be considered when planning the works and preparing the Health and Safety plan.

All equipment used when working on AC pipes must be suitable for the works, well maintained, and operated by trained and competent users.

Table 5-1 – Controlled Equipment: Hand Tools

Advantages	
Lower risk of dust generation	Provided the pipe surface is wet throughout cutting – using hand tools presents a lower risk of dust generation.
Appropriate for small and low pressure-class pipes	Hand tools are generally appropriate for cutting small (< DN 200) and low pressure-class pipes.
No wet slurry is generated	No wet slurry is generated when using these hand tools.
Disadvantages	
Extended shut-down period required	Hand tools are highly likely to prolong the shut-down time and so may not be helpful where short shut-down periods are essential (e.g. critical / lifeline pipelines).
Increased exposure to asbestos	When using hand tools, workers have increased exposure time to asbestos.
Labour intensive	Using hand tools may be labour intensive.
Not appropriate for large and high pressure-class pipes	Hand tools are not generally appropriate for cutting larger (≥ DN 200) and high pressure-class pipes. Using hand tools on these pipes presents increased exposure time to asbestos and tiring work (especially when breathing through a P3 mask). Alternative cutting methods should be considered.
Examples of Equipment	

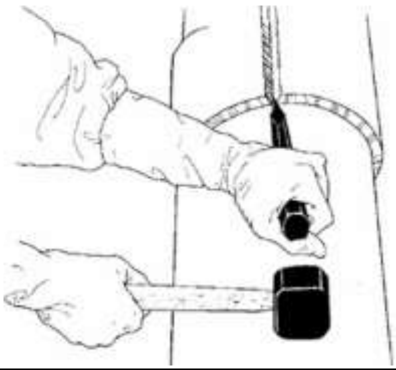

Table 5-2 – Controlled Equipment: Chain Pipe Cutter

Advantages	
Lower risk of dust generation	Chain cutters present a lower risk of dust generation.
Appropriate for small and low pressure-class pipes	Chain cutters can be appropriate for cutting small (< DN 200) and low pressure-class pipes.
Lower exposure time to asbestos	Generally lower exposure time is experienced.
Can be used on large and high pressure-class pipes	Mechanical chain cutters – Up to approximately DN 250. Hydraulic chain cutters – Greater than approximately DN 250. Quick process provided the pipe has not softened and lost structural strength.
Disadvantages	
May be difficult to make a clean and square cut	The cut ends are relatively jagged, however, usually "square" to the axis. Additional cutting and preparation work can be necessary for pipe sample testing.
Not suitable for phenolphthalein testing	Additional cutting and preparation work is typically necessary to obtain a reliable deterioration depth measurement. There is also increased exposure time to asbestos.
May not be suitable for thinner walled and softened AC pipes	Thin walled and softened AC pipes can be crushed by chain cutters. A trial "Cut" should be made to determine if chain cutting is practicable.
Example of Mechanical Chain Cutter	

Table 5-3 – Controlled Equipment: Petrol Powered Cut-Off Saw

Advantages	
Short shut-down period required	Where short shut-downs periods are essential (e.g. critical / lifeline pipelines) this is the most efficient method to ensure service is returned as soon as possible. Hand tools and pipe chain cutting methods are usually too slow to enable the water supply to be restored in a timely manner.
Lower exposure time to asbestos	Of the three methods (especially for the larger diameter pipes) the worker's exposure time is significantly reduced compared to cutting with hand tools or chain pipe cutters.
Lower risk of dust generation	Provided there is adequate water supply to ensure the pipe surface remains flooded throughout the cutting, the likelihood of dust being generated and becoming airborne is minimal (the slurry should be contained).
Large and high pressure-class pipes	Wet cutting large diameter pipes minimises the workers exposure time. Larger diameter pipes (>DN 200) and higher pressure-class pipes have the thicker walls and wet cutting minimises the workers exposure time.
Appropriate for small and low pressure-class pipes	Minimal exposure time for the works.
Achieving a clean square cut	Further / additional cutting of the pipe for repair work or crush testing samples is not generally required (if care taken when cutting). Significantly reduces the likelihood of additional dust generating preparation works.
Cut surface is suitable for pipe sample testing	Usually minimises exposure time of the worker(s) in preparation for testing and significantly reduces the likelihood of additional dust generating preparation works.
Disadvantages	
Exhaust fumes in a trench – potential confined space issue	Mitigation measures are to be in place prior to commencing to ensure there is adequate ventilation for the operation of the petrol powered equipment.
Inadequate flow of water, could generate airborne dust	A continuous stream of water should be applied to the AC pipe surface for the duration of the cut. If water supply is lost, works should cease immediately.
Drying out of wet slurry	If slurry dries out, asbestos dust can become airborne. Slurry can be contained in the trench or captured on PE sheets, sealed and safely disposed of.

Table 5-3 – Controlled Equipment: Petrol Powered Cut-Off Saw – **Cont'd**

Example of Petrol Powered Cut-Off Saw


Table 5-4 – Controlled Equipment: Under Pressure Tapping (Incl. Core Sample Recovery)

Advantages	
Low risk of dust generation	A well designed under-pressure taping tool contains water and AC slurry
Pipelines does not require shut down	No shut-down required and a sharp, tungsten carbide tipped hole saw will quickly cut through AC pipe.
Cut surface is suitable for pipe sample testing	In general the core sample is ready for a phenolphthalein test as soon as it has been washed clean of slurry.
Generation of / drying out of wet slurry	Slurry is contained in the coring tool and can be washed off readily along with all other hand tools.
Example of a Under Pressure Coring Tool	
	

5.9 Safe Disposal of Asbestos Pipes and PPE

At the conclusion of each working session, carefully remove disposable PPE and seal in a plastic bag along with all other residues from the session.

After testing and assessment, double bagged and sealed pipe or core samples and disposable PPE should be disposed of at a licensed hazardous waste facility.

Refer to the Health and Safety at Work (Asbestos) Regulations 2016:

- Clauses 40 and 50: Duties relating to disposal of asbestos waste and contaminated personal protective equipment.

Refer to the Management and Removal of Asbestos Approved Code of Practice:

- Section 17: Decontamination (work area and personal).
- Section 18: Waste containment and disposal.

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