CONSTRUCTION SPECIFICATIONS

FOR PILING

PREPARED FOR

THE MARINE WORKS SECTOR OF

PUBLIC WORKS CANADA

Ottawa, Ontario, K1A OM2

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GUIDELINES

for writing

CONSTRUCTION SPECIFICATIONS

FOR PILING

A Continuing Education Short Course text

DEEP FOUNDATIONS INSTITUTE

P R E F A C E

This document has been prepared for Public Works Canada, Marine Works Sector. It is the intent that it upon formal approval will become a Canadian National Master Specification. The Deep Foundations Institute is grateful to the Public Works Canada, Marine Works Sector, for the permission to reprint and disseminate the document.

The specifications follow the standard format of the Master Specifications. That is, Spec Notes are frequently interspersed in the text to provide explanation and advice to the designer adapting the master specs to a project. The Spec Notes and any irrelevant clauses are to be deleted before the particular project specs are completed.

In writing the master specifications, much effort has been placed on referring to requirements which are quantifiable. For instance, a pile driving hammer is not specified by a rated energy value, but by the energy to be transferred to the pile and by the impact force to be delivered to the pile, which are measurable quantities. Further, limits for bending and doglegging of a pile have been defined by a specific bending radius, and straightness and out-of-location have been given specific tolerances. It is expected that use of the specifications will significantly reduce the incidence of disputed construction claims in the piling field.

PART 3 EXECUTION

3.1 Equipment

.1 Equipment information

.1.1 Prior to commencement of pile installation operation, submit to [Engineer] for [approval] [review], details of equipment for installation of piles.

SPEC NOTE: The information requested in 3.1.1.2 is necessary as input to a detailed wave equation analysis of the pile driving.

.1.2 For impact hammers, give manufacturer's name, type, maximum rated energy and rated energy per blow at normal working rate during easy and at termination driving, mass of striking parts of hammer, mass of driving cap, and type and elastic properties of hammer cushion.

.1.3 For non-impact methods of installation, such as drilling, jacking, jetting, use of vibratory hammers, or other means, give full details of characteristics necessary to evaluate performance.

.2 Impact Hammer

SPEC NOTE: Do not exclude a hammer type unless for very specific reason.

.2.1 For final driving of [TYPE] piles, provide a hammer capable of delivering to the pile a non-erratic impact stress not smaller than [VALUE] Pascal and transferring a non-erratic energy not smaller than [VALUE] Joules per blow to the pile head at normal working rate. [Drop hammers will not be permitted.] [Diesel hammers will not be permitted.]

SPEC NOTE: Bounce-chamber gages in double-acting diesel hammers are frequently inaccurate.

.2.2 For air/steam hammer and double-acting diesel hammer, provide a calibrated pressure gage and position the pressure gage on the hammer side of all valves, with no more than 30 m of hose away from the hammer intake, and so it can be easily observed by [Engineer]. Provide a calibration certificate of the pressure gage that is current within 6 months.

SPEC NOTE: For driving of concrete piles, where tensile stresses are of concern in easy driving, include 3.1.2.3. For both ordinary precast concrete piles and prestressed precast concrete piles, the limiting driving tension is governed by the yield strength of the reinforcement with no

allowance for tensile strength of the concrete. Therefore, the maximum tensile resistance in a driven concrete pile is equal to the axial tension capacity of the reinforcing bars or of the prestressing strands. When applying a factor of safety of about 1.4, the maximum allowable tensile stress is 70 % of the steel yield. Coincidentally, this percentage is about equal to the net prestress in a prestressed pile.

.2.3 The hammer shall be adjustable to delivering a reduced impact so that during easy driving of the pile, when tensile stresses are of concern, the largest reflected tensile stress is at all times smaller than [VALUE] Pascal.

SPEC NOTE: Include Clause 3.1.2.4 when sheet piles are to be installed. Requirements for delivered impact force and transferred energy are different for sheet piles as opposed to bearing piles.

.2.4 For installation of sheet piles, provide installation equipment capable of installing sheet pile to elevations indicated.

.2.5 Approval of the hammer equipment will be subject to [Engineer's] assessment of the results of the dynamic monitoring of the pile driving using the Pile Driving Analyzer, as described in Clause [3.13].

.2.6 Remedial action due to failure of the Contractor's hammer equipment to satisfy the requirements in Clause [3.1.2] will be at the Contractor's own expense. Such remedial action may consist of, but need not be limited to, adjustment or replacement of hammer cushion, or of pile cushion, or to adjustment or replacement of hammer.

.3 Vibrohammer

.3.1 Use vibrohammer only with [authorization] [permission] of [Engineer].

.3.2 When vibrohammer is [authorized] [permitted], install pile by means of vibrating to depth indicated by [Engineer] and restrike pile by means of impact hammer until reaching penetration resistance specified by [Engineer].

.4 Leads

.4.1 Provide leads that will enable the hammer to deliver impacts concentrically and in alignment with the pile longitudinal axis without inducing rocking movements or bending moments in pile.

.4.2 Provide fixed leads held in position at or near the top and at or near the bottom except where swinging leads are authorized by [Engineer].

.4.3 Provide leads that are parallel and not bent beyond a 15 mm deviation from a straight line over any 5.00 m length (0.3 %).

.4.4 Provide leads of sufficient length to accommodate the combined length of pile and hammer.

.4.5 Performance of the leads will be subject to assessment of [Engineer]. Any remedial action required will be at the Contractor's own expense.

.5 Follower

.5.1 Do not use follower without [Engineer's] permission.

.5.2 When permitted, provide follower with dynamic impedance (EA/c) equal to that of pile and of shape and length enabling driving of pile in specified location to required depth and resistance. Provide follower with socket or hood carefully fitted to the pile head to minimize loss of energy and prevent damage to pile.

.5.3 Where follower is to be used, drive applicable test piles using similar follower.

.5.4 Proper design and performance of follower will be subject to the assessment of [Engineer] which may include dynamic monitoring using the pile driving analyzer as described in Clause [3.13]. Any remedial action found necessary will be at the Contractor's own expense.

SPEC NOTE: Include 3.1.6 for long, closed-toe, pipe piles and for concrete piles equipped with center tubes. The mandrel probes hould be designed to react to pile bending by jammming in the pile as described by the Canadian Foundation Engineering Manual (1985), Chapter 24, Section 24.3.3.

SPEC NOTE: The mandrel probes will react to other causes than bendin, such as a local change of ovality and/or dent in the pile inside surface or in the center tube. Therefore, failure of the mandrel probe to reach the full length of the pile does not necessarily indicate an excessive bending or doglegging of the pile. The probing is intended to separate piles that need further assessment from pile which are considered straight and undamaged. Notice also that the probing does not indicate anything of the condition of the pile below the bottom of the mandrel probe.

SPEC NOTE: The proposed 200 m and 100 m radii represent severe curving of a pile. However, mandrel probes should not be designed to react for smaller curvature (larger radii), because such probes will be very cumbersome to use in practice. If bending would be very important for a project, use of special inclinometers should be considered instead.

.6 Inspection by means of mandrel probes

.6.1 Provide two inspection probes for use for pile inspection. The probes shall be made from heavy steel pipe and have dimensions length [ ] metre ("Probe Radius 200 m") and [ ] metre ("Probe Radius 100 m") and outside diameter [ ] mm ("Probe Radius 200 m") and [ ] mm ("Probe Radius 100 m").

.6.2 After initial driving of pile, lower the probe marked "Probe Radius 200 m" into [pile] [center tube] to the toe of the pile. If the probe fails to reach the toe, record depth of stop, and proceed to lower the probe marked "Probe Radius 100 m".

.6.3 Pile in which the "Probe Radius 200 m" fails to reach the pile toe may be rejected subject to the assessment of [Engineer]. Such assessment may involve inspection by means of a TV camera and/or measurement of pile curvature by means of inclinometer.

3.2 Preparation

.1 Ensure that ground conditions at the pile locations are adequate to support pile driving and loading-test operations. Make provision for access and support of piling equipment during performance of work.

.2 Do not commence pile driving before excavation has been completed.

.3 Do not drive piles within embankments until embankment has been placed and compacted to at least bottom elevation of pile cap.

3.3 Field Measurements

SPEC NOTE: Delete or modify to suit project.

.1 Maintain accurate and daily records of driving for each pile, including:

.1.1 Type, make, and rated energy of hammer.

.1.2 Other installation equipment including details on use of pile cushion, follower, and water jet.

.1.3 Pile size and length, location of pile in pile group, and location or designation of pile group.

.1.4 Time for start and finish of driving pile and sequence of pile driving for piles in group.

.1.5 Penetration for own weight and own weight and weight of hammer, number of blows per 300 mm of penetration from start of driving, and penetration for [four] consecutive series of [ ] blows when approaching termination of driving of pile.

SPEC NOTE: The blow rate of a single-acting dieslel hammer is an indication of the ram travel length (ram stroke) and a very important observation for determining that the hammer is working at the proper setting to limit damaging stress and achieving capacity. Simple equipemnt is available commercially to continuously monitor and record the hammer blow rate.

.1.6 Observed stroke and blow rate (blows/minute) of hammer.

.1.7 Toe elevation upon termination of driving pile and final toe and cut-off elevations upon completion of pile group.

.1.8 On termination of the driving of open-toe pipe piles, record depth from ground surface outside pile to soil surface inside pipe.

.1.9 Records of restriking.

.1.10 Result of inspection of pile by means of inspection probe, as described in [3.1.6].

.1.11 Other pertinent information, such as interruption of continuous driving, observed pile damage, etc.

.1.12 Records of elevation of adjacent piles before and after driving of pile.

.1.13 Record all information on forms provided by [Engineer]

.2 Provide [Engineer] with three copies of the records.

3.4 Pile Installation

.1 Use driving helmet to protect pile head and guide hammer to pile.

.2 Do not use any loose inserts in the helmet. The Engineer is sole judge of the acceptability of the helmet.

.3 Hold pile securely and accurately in position while driving.

.4 Deliver hammer impacts concentrically and in direct alignment with pile taking care to avoid forcing pile laterally or bending pile. If, in the Engineer's opinion, lateral or bending forces unduly affect the pile, the Contractor must stop and rectify the situation at his own expense and to the satisfaction of the Engineer.

.5 Reinforce pile heads, if and as necessary.

.6 Advance pile to [toe elevation as indicated on drawing] [penetration resistance specified in Clause [3.9]].

.7 Do not drive piles within a radius of [8] metre of concrete which has been in place for a time shorter than [3] days unless authorized by [Engineer].

.8 Exercise care when driving inclined piles adjacent to existing structures to ensure that no contact between pile and structure takes place.

SPEC NOTE: Delete 3.4.9 unless it is clearly applicable to project.

.9 Do not drive inclined piles until vertical piles within a radius of [VALUE] metre have been fully driven.

.10 Restrike piles which have settled or heaved during driving of adjacent piles. No additional compensation will be made for pile restruck due to such settlement or heave.

SPEC NOTE: Restriking of piles is a valuable inspection tool and it should be considered for all piling projects. It will be useful to determine that no relaxation has occurred and it may also be used to check that soil set-up has occurred. Notice, however, that for piles which have been driven to a high resistance at end of initial driving, the restrike "blow count" may not reveal the presence of any appreciable amount of soil set-up.

SPEC NOTE: Restriking of piles may involve the use of a separate pile driving hammer and extensive movement of the pile driving equipment and, therefore, infer considerable costs. It is recommended that the initial restriking experience be reviewed by the Engineer to determine if continued restriking is necessary and cost effective.

.11 Restrike piles as directed by [Engineer].

.12 Remove loose and displaced material from around piles after completion of driving, and leave clean, solid surfaces to receive foundation concrete.

.13 Provide sufficient length above cut-off elevation so that part damaged during driving is cut off. Cut off piles neatly and squarely at elevations indicated.

SPEC NOTE: Include Clause 3.4.14 for closed-toe pipe piles and precast concrete piles equipped with center tubes.

.14 After driving, pile must be accessible for inspection of integrity and bending through the full length of pile. Presence of any foreign material and water is a cause for rejection of the pile at the discretion of [Engineer].

.15 Remove cut-off lengths from site on completion of work.

3.5 Temporary Bracing and or Templates

SPEC NOTE: Delete or modify to suit project.

.1 Provide all bracing and/or templates necessary for the installation of piles.

.2 Bracing and or templates must be capable of providing the necessary support to piles during initial installation and restriking, as well as during socketing, grouting, and concreting work until pile is a part of final structure.

.3 Bracing and templates must be capable of keeping pile within tolerances specified in Clause [3.10].

.4 Bracing and templates must not be removed until the concrete cap beams have been cast and the concrete reached a strength of [VALUE] MPa.

.5 Support cantilever piles as necessary. Do not leave inclined, cantilevered piles unsupported.

.6 Remove temporary bracing and templates upon completion of work.

.7 Plant, labor, equipment, material, and supervision costs related to providing temporary bracing and or templates are incidental to the piling work and no additional compensation will be made.

3.6 Obstruction

.1 Where obstruction is encountered that results in sudden, unexpected change in penetration resistance and deviation from specified tolerances, the Contractor may be required to perform one or all of the following:

.1.1 Removal of obstruction.

.1.2 Extraction, repositioning, and redriving.

.1.3 Addition of extra piles.

.2 If in the opinion of [Engineer] work done as per Clause [3.6.1] could not have been reasonably anticipated by the Contractor, additional compensation for work done will be considered for payment.

3.7 Jetting

SPEC NOTE: Jetting of piles will frequently speed up installation, reduce risk of damaging piles in prolonged driving, and reduce risk for bending of piles. However, for long piles, only internal jetting will ensure these benefits and external jetting should normally not be used.

.1 Use water jetting only with [authorization] [permission] of [Engineer].

.2 When water jetting is [authorized] [permitted], the jetting system used must be sufficient to freely erode and remove the soil material immediately adjacent to the pile without creating a crater around pile causing it to drift.

.3 Submit all details of jetting including plant description, the number and size of jet nozzles (size to be accurate to 1 mm), volume and pressure of water, and size and length of water hoses and pipes to [Engineer] for [approval] [review].

.4 Restriction: stop jetting at a minimum of [1] metre above expected final toe elevation and at a minimum of [1] metre above the toe elevation of piles previously driven within [2] metre of jetted pile, except where piles are carried to bedrock. Drive piles down beyond depth of jetting until required penetration resistance is obtained. If there is evidence that jetting has disturbed previously installed piles, restore capacity of those piles by restriking. Restrike for verification where necessary after jetting operations in area have been completed. No additional compensation will be made.

3.8 Working Load

.1 The required working load of each pile is [VALUE] KN [as follows:]

3.9 Penetration Resistance

.1 Installation of each pile will be subject to [approval] [review] of [Engineer], who will be sole judge of acceptability of pile with respect to penetration resistance at end-of-initial-driving as well as at restriking, to depth of penetration, or to other penetration criteria. [Engineer] to [approve] [review] final penetration resistance of all piles prior to removal of pile driving equipment from site.

.2 [Engineer's] assessment of penetration resistance [will] [may] necessitate dynamic monitoring using the Pile Driving Analyzer, as described in Clause [3.13].

SPEC NOTE: Select and modify 3.9.3 through 3.9.8 to suit project.

.3 Drive each pile to a final penetration resistance during initial driving of at least [120] blows for [three] consecutive penetrations of 300 mm, or to a penetration resistance of at least [200] blows for a penetration smaller than 300 mm, or to a penetration smaller than 25 mm for [two] consecutive series of [50] blows, whichever occurs first.

.4 Drive each pile to a final resistance measured in penetration for [three] consecutive series of [20] blows. The required penetration will be established by [Engineer] from results of [dynamic monitoring] [and] [static loading test] as described in Clause [3.13] and Section [02356], respectively.

SPEC NOTE: Soil set-up may develop during pauses in the pile driving to change cushion, splicing a new segment on to a pile, etc. Such soil-set-up may cause the penetration resistance to increase and become unrepresentative for the termination criterion assigned to the piling work.

.5 Prior to taking final penetration resistance, drive piles without interruption for a sufficient interval to break or prevent any soil set-up that may have developed.

.6 Maintain a hammer blow rate of at least [VALUE] blows/minute at final penetration resistance

.7 To avoid overstrssing the pile, ensure that the hammer blow rate is larger than [VALUE] blows/minute at all times.

.8 Drive each pile a minimum length of [VALUE] metre. In measuring such minimum length, do not include penetration caused by the weight of pile and hammer alone.

.9 Drive each pile to a minimum [toe penetration of [VALUE] metre] [toe elevation of [+ VALUE]] [as indicated].

SPEC NOTE: In restriking piles when soil set-up has developed, the termination criterion applied in initial driving may be found insufficient. A wave equation analysis supported by static analysis and dynamic monitoring results will then be necessary to determine the acceptance criterion for restriking conditions.

.8 When required by [Engineer], restrike piles to [the same criterion as applied in initial driving - Clause [3.9.3]] [to a penetration of [VALUE] mm for [three] consecutive series of [20] blows]. No additional compensation will be made for restriking.

3.10 Tolerances

.1 Pile heads, at cut-off elevation, to be within [75] mm of locations indicated, [as measured immediately after termination of initial driving, and [150] mm as measured after all piles have been driven]. [To achieve pile installation within tolerances specified, the Contractor may have to resort to using temporary bracing and templates, as specified in Clause [3.5].

.2 Pile, at cut-off elevation, to be no more than [2] % of length out of alignment.

SPEC NOTE: Clause 3.10.3 applies to pipe piles and to concrete piles equipped with a center tube.

.3 Piles must not be bent beyond a bending radius of 200 m, as determined by means of the inspection probe detailed in Clause [3.1.5] to be provided and used by the Contractor, or determined, additionally, by means of inclinometer measurements performed by [Engineer].

SPEC NOTE: Include 3.10.4 for soldier piles on specific occasions.

.4 Pile rotation to be limited to [VALUE] degrees.

.5 Maintain piling within tolerances specified throughout execution of work.

SPEC NOTE: Clause 3.10.6 addresses location of an individual pile immediately after its placement. Misallocation of groups of piles and

individual piles due to drifting after placement should be addressed separately, as it often is due to causes beyond the Contractor's control.

.6 If in the opinion of [Engineer] piles are placed beyond tolerances specified, the Contractor may be required to remove such piles and install new piles to the specified tolerances at his own expense.

3.11 Damaged or Defective Piles

SPEC NOTE: A pile, which is rejected for reasons of inadequate capacity, out-of-location, damage, and/or bending must not be connected to the pile cap. It will not contribute to the capacity of a group or reduce settlement but, instead, be a liability to the non-defective piles.

.1 [Engineer] will reject any pile found to be defective or damaged.

.2 Remove rejected pile and replace with a new [and, if necessary, longer] pile.

.3 Remove rejected pile and fill hole as directed by [Engineer].

.4 Leave rejected pile in place and cut off as directed by [Engineer].

.5 Leave rejected pile in place and place adjacent pile as directed by [Engineer].

.6 No extra compensation will be made for removing and replacing or other work made necessary through rejection of a defective pile.

3.12 Loading Test

SPEC NOTE: Include Clause [3.12] when a loading test is required.

SPEC NOTE: It is usually desirable to combine static and dynamic testing on a project, having a ratio of several dynamic tests for each static test. It is then important that dynamic monitoring is performed on the pile selected for static test and that the test pile be restruck after the static test with dynamic monitoring.

.1 Provide static or dynamic loading test on [number] pile(s) as selected by [Engineer] and at any time during performance of work.

.2 Arrange and perform static loading test in accordance with Section [02356].

.3 Arrange and perform dynamic test in accordance with Clause 3.13].

.4 Failure of loading test to show satisfactory performance due to inadequate equipment and or arrangement will result in rejection of test and testing of additional piles.

3.13 Pile Driving Analyzer

SPEC NOTE: It is not possible to say beforehand that no problems or disputes will occur a specific site, and for that reason, it is not possible to say that monitoring is not going to be helpful or required at piling project. Therefore, dynamic monitoring should be considered for all projects involving driven piles and all projects should include specifications on dynamic monitoring albeit with option not to use it or to use it only to a limited extent. Notice, dynamic monitoring is not just to determine pile capacity, it is also an important part of the pile inspection and required for verifying that the pile diving hammer is working correctly and consistently, that driving stresses are adequate, and the soil response as anticipated in the design.

SPEC NOTE: Dynamic monitoring should always be contracted separately with a specialist monitoring company and not be a responsibility of the piling contractor.

SPEC NOTE: Dynamic monitoring includes static analysis and wave equation analysis performed before the monitoring work and appropriate to the site (actual soil, hammer, and pile data to be used in the analyses). Further, selected records obtained in the monitoring work are to be subjected to detailed CAPWAP computer analysis. These aspects must be included in the separate instructions to the monitoring company. ASTM D4945 contains information and recommendations for the performance of dynamic monitoring.

SPEC NOTE: The Contractors costs for dynamic monitoring at initial driving differ from costs during restriking, which may require special movement of the equipment. Therefore, it is necessary to indicate whether or not the monitoring will occur during initial driving or at restriking.

.1 Dynamic monitoring of the pile driving using the Pile Driving Analyzer will be used on [[ten] piles during initial driving and on [ten] piles during restriking] [15 % of all piles] as selected and directed by [Engineer].

.2 The dynamic monitoring will be used to indicate the performance of the hammer, calculate the transferred hammer energy and the driving stresses in the pile, estimate the mobilized capacity of the piles, provide information for analysis of pile integrity, and assist in determining the required final penetration resistance in initial driving and in restriking.

.3 The Contractor shall co-operate to ensure that the schedule for the dynamic monitoring is adhered to by providing all related access and assistance to enable the testing company to expeditiously perform the monitoring.

.4 The dynamic monitoring consists of attaching strain transducers and accelerometers to the pile, usually close to the pile head, and connecting these to a monitoring station on the ground by means of a cable. Care must be taken to ensure that no damage is done to the transducers, cables, or equipment.

.5 The preparation of the pile head will be done by the testing company, usually while the pile is on the ground. The preparation consists of drilling and tapping holes in the pile. The transducers are normally attached after the pile is secured in the leads. The Contractor shall assist the testing company in providing a man to climb the leads carrying the transducers and cable and attaching the transducers by bolting them to the holes. The testing company will instruct the Contractor in the details of this work. Attaching the transducers to the prepared pile head requires installation of a total of seven threaded bolts into the prepared holes. Before commencement of pile driving, the testing company will check that all connections are functioning. Occasionally, the driving may have to be temporarily interrupted for the transducers to be adjusted or replaced, or the monitoring results assessed. Such interruptions do not constitute a new monitoring event.

.6 No additional compensation will be made for dynamic monitoring specified in Clause [3.13.1].

SPEC NOTE: It is frequently necessary to perform dynamic monitoring beyond the amount anticipated in the design. Payment must therefore separate between compensation for monitoring according to Clause [3.13.1] and compensation for additionally requested monitoring. Such monitoring may be carried out during initial driving and/or during restriking.

.7 Monitoring beyond the amount specified in Clause [3.13.1] will be measured for additional compensation.

3.14 Pile Integrity Measurements

SPEC NOTE: Questions about the soundness of piles often arise, be the piles driven or bored. When questions do arise, it is important to have the means to perform integrity measurements with option not to use it or to use it only to a limited extent. The option of performing such measurements should, therefore, be included in the specifications.

SPEC NOTE: For driven piles, assessment of pile integrity is included in the high-strain dynamic monitoring provided by the Pile Driving Analyzer. The integrity can also be checked by means of low-strain measurements applicable to both driven and cast-in-situ piles. Precast concrete piles can be checked for hidden defects before driving.

SPEC NOTE: Low-strain integrity measurements should always be contracted separately with a specialist testing company and not be a responsibility of the piling contractor.

SPEC NOTE: Low-strain integrity measurements includes analysis of borehole records and include measurements on many more piles than tested by means of the Pile Driving Analyzer. Further, selected records are to be subjected to detailed computer analysis, so-called PITWAP analysis. These aspects must be included in the separate instructions to the monitoring company.

.1 Low-strain integrity measurements [may] [will] be performed after the concrete has cured for [72 hours] on [all] [75 % of the] piles as selected and directed by [Engineer]. The measurements will be performed by an independent firm. The Contractor is to provide access to the pile head and to finish the pile head with a smooth upper surface onto which the accelerometer will be placed.

.2 The low-strain integrity measurements will be used to provide information for analysis of pile integrity. They involve attaching an accelerometer to the pile head and connecting the accelerometer with a cable to a data acquisition unit. Measurements are initiated by striking the pile head with a small hand-held hammer.

.3 The Contractor shall co-operate to ensure that the schedule for the low-strain integrity measurements is adhered to by providing all related access and assistance to enable the testing company to expeditiously perform the measurements.

.4 No additional compensation will be made for low-strain integrity measurements specified in Clause [3.14.1].

SPEC NOTE: It is frequently necessary to perform integrity measurements beyond the amount anticipated in the design. Payment must therefore separate between compensation for low-strain integrity measurements according to Clause [3.14.1] and compensation for additionally requested measurements.

.5 Low-strain integrity measurements beyond the amount specified in Clause [3.14.1] will be measured for additional compensation.

PART 1 GENERAL

SPEC NOTE: This specification section refers to static loading tests. For dynamic testing of piles, see Section 02351.

SPEC NOTE: A routine static test does not provide information on the capacity of the tested pile unless the pile is tested to failure. If the information is to be used for anything beyond proof testing purposes, testing to failure is desirable.

SPEC NOTE: Use of a static loading test is not in conflict with nor precludes the use of other types of tests, such as dynamic testing (a part of dynamic monitoring). In fact, combining the static test with other methods can frequently reduce cost (by reducing the number of static tests, which are expensive) while increasing the amount of information obtained from the testing.

1.1 Related Work

.1 [ ] Section [ ]

1.2 Reference Standards

.1 All pile testing must be arranged and performed in conformance with requirements in appropriate ASTM standards and the Canadian Foundation Engineering Manual (1985).

.2 Do axial compressive static loading test in conformance with ASTM D1143-81 except where specified otherwise.

.3 Do axial tension static loading test in conformance with ASTM D3689-83 except where specified otherwise.

.4 Do lateral static loading test in conformance with ASTM D3966-81 except where specified otherwise.

1.3 Shop Drawings

SPEC NOTE: In particular the arrangement of the static loading test is often lacking, jeopardizing the reliability of the test results. It is necessary that the specifications emphasize proper arrangement of the test. Timely submitted shop drawings are important to ensure that deviations from the standards can be discovered and corrected in time.

.1 Submit shop drawings indicating the arrangement of the test and all design calculations stamped by a professional engineer not later than [14] days prior to commencing the test.

1.4 Method of Measurement

SPEC NOTE: Mobilization and de-mobilization is a substantial part of the costs for a static loading test. Therefore, if there is any possibility that the number of tests may vary, mobilization and demobilization of tests should be indicated separately from the tests.

.1 Mobilization and de-mobilization will be measured as a single, fixed item.

.2 Measure pile test by number of piles tested.

PART 2 PRODUCTS

Not applicable.

PART 3 EXECUTION

3.1 General

SPEC NOTE: Static loading test on inclined piles are very expensive and should not be required unless shown to be necessary.

.1 Perform loading test on pile(s) selected by [Engineer] at any time during work.

.2 Supply equipment, temporary structures, and reaction capacity necessary for performing test as indicated in the appropriate ASTM standard—a 2.5 metre minimum free distance is required between the supports of the reference beams, piles, and cribbage. Use of two separate, unconnected reference beams, etc. are also mandatory. [Engineer] will verify that minimum distances and tolerances indicated in the ASTM standard have been complied with and arrangements found inadequate must be rectified by Contractor prior to commencing test.

.3 If in the Engineer's opinion, the test arrangement is unstable or unsafe, such deficiency must be rectified by the Contractor prior to commencing test.

.4 Supply separate load-cell of proven ability to function under field conditions. Submit details on load-cell to [Engineer] for approval not later than [14] days prior to commencing test.

SPEC NOTE: When a properly functioning load-cell is used, the load measured by the jack pressure is a back-up measurement. Therefore, the jack does not need to be calibrated prior to the test, only the pressure gage (manometer).

.5 Submit details of jack and calibrations of jack manometer and load-cell not later than [14] days prior to commencing test.

.6 Supply all dial gages and necessary appurtenances required for measuring movement [and pile compression] during the loading test. Dial gages must have a travel of at least 50 mm, a reading precision of 0.01 mm, and be certified to be accurate to 0.05 mm. Supply, also, an adequate number of gage blocks (shims) made of metall or glass to increase the travel to at least an additional 100 mm per dial gage.

.7 In lieu of dial gages in SI-units, gages showing gradation in English units are accepted. Such dial gages must have a travel of at least 2.00 inches, a reading precision of 0.001 inch, and be certified to be accurate to 0.002 inch. Gage blocks (shims) should be supplied to increase the travel to at least an additional 4.0 inches per dial gage.

.7 The manometer measuring the jack pressure must have a range that is greater than [120] % of the maximum test pressure and smaller than [135] % of the maximum test pressure.

.8 The division of the manometer must be [0.5] % of the manometer range, or smaller, and the maximum error of the manometer must be [1.0] %, or smaller.

SPEC NOTE: The use of two jacks easily induces instability into the loading set-up. More than two jacks should not be permitted.

.9 Use a single jack to provide the applied load unless authorized by [Engineer] to use a pair of jacks.

.10 Supply qualified operator and labour to operate equipment throughout duration of test as instructed by [Engineer].

.11 Provide suitable enclosure of test [platform] [arrangement] to ensure complete weather protection for reference beams and for personnel conducting test. Provide necessary power source, lights, and heating.

.12 Do not commence compression test earlier than [10] days nor later than [28] days after initial driving of pile.

.13 Do not commence tension test earlier than [14] days nor later than [28] days after initial driving of pile.

.14 Do not commence lateral test earlier than [14] days nor later than [28] days after initial driving of pile.

.15 Do not commence test on socketed pile until [5] days after grout has been placed.

.16 Carry out test in accordance with Clause [3.3] and under supervision of [Engineer].

SPEC NOTE: Restriking a pile after a loading test is completed can provide important information adding to the value of the test. In particular, if the restriking is combined with dynamic monitoring.

.17 Upon completion of test, restrike test pile [as indicated in [Section 02351]] [as directed by [Engineer] [while monitoring pile by means of the Pile Driving Analyzer as indicated in [Section 02351]].

3.2 Instrumentation

SPEC NOTE: The results of routine loading tests can be enhanced considerably if compression of the pile were to be measured by means of telltale(s). There are many ways to arrange for telltale measurements and the clauses below serve only as approximate guide. Details will have to be given in the sections on the special pile types for the project. Note, when telltales are used, performing a tension test immediately following a compression test on the same pile will provide valuable data for analysis.

.1 The test pile will be equipped with [two] telltales for measuring pile deformation during the loading test. Details on the telltale arrangement are given in Section [ ].

.2 The telltale readings of pile deformation will be taken simultaneously with the measurements of applied load and movement of pile head and require dial gages of arrangement and accuracy similar to those recording pile head movement.

SPEC NOTE: Telltale measurements can be arranged to provide a direct measurement of either pile toe movement or pile deformation (shortening for a compression test and lengthening for a tension test). The two values are related via the measurement of pile-head movement. Because in the analysis of the test data the pile deformation is the most sensitve value, the gages must always be arranged to measure pile deformation directly, leaving the pile toe movement to be determined from combination of pile head movement and pile deformation.

.2 The dial gages recording telltale readings must be oriented so as to read defomation rather than toe movmeent.

3.3 Testing Method

SPEC NOTE: The ASTM standards contain several testing methods, ASTM D1143 no fewer than seven, and the method to use must be specified in detail. The "Quick Load Test Method" is the preferred method, technically and economically. This method, with details as specified in Clause 3.3, consists of using 25 to 35 small increments

applied at constant, short time intervals. The intervals should not be shorter than 5 minutes nor longer than 15 minutes, 10 minutes is a preferred interval that allows for study of "creep" deformation for eachload level.

SPEC NOTE: Clause 3.3 applies to both compression testing and tension testing. The specified values of load to apply will be different for the two test types, however.

SPEC NOTE: The maximum test load is usually 2.00 times the working load, sometimes 2.50 times. Note, it is often desirable to design a test so that the pile can be loaded to failure.

.1 Contractor must not subject the pile to any loading prior to starting the test.

.2 Do [compression] [tension] test in accordance with the "Quick Load Test Method" specified in ASTM [D-1143-81] [D3681-83].

.3 Load pile in equal increments of [VALUE] newton applied at exactly every [10] minutes until a maximum load of at least [VALUE] newton. Each load level to be accurately maintained. Should the loading increment accidentally become too large, the load must not be released, but the load level be recorded and the readings be taken at this load level and the next loading increment be correspondingly smaller.

.4 Within each load level, take simultaneous readings of movements and load at [3, 6, and 10] minutes after start of loading. Should the applied load accidentally become too large, the load must not be lowered, but readings be taken at this higher load level.

.5 When the maximum test load has been kept on for exactly [10] minutes (time elapsed after start of loading), or if the pile head has moved more than [120] mm, unload pile in five approximately equal decrements of load at every [3] minutes while recording movements and load for each load level at the end of each 3-minute period.

.6 Continue recording movement gages at every [10] minutes during at least [30] minutes after completed unloading of pile.

.7 [Engineer] may require a quick reloading of pile to the maximum test load immediately the first test is completed. The reloading test will involve fewer load increments and be over in about 2 hours. The Contractor will receive no additional compensation for such reloading.

3.4 Test Evaluation

.1 [Engineer] will be sole judge of test.

SPEC NOTE: Provided that the testing method is the quick maintained-load and that a load-cell is used to determine load, usually, the criterion for acceptance of the pile is based on reaching a load of 1.80 times the working load at a movement equal to or smaller than the offset limit movement calculated as given in Clause 3.4.2. ***In addition****, plunging failure must not occur at a load smaller than 2.00 times the working load, as required in Clause 3.4.3. These two values, 1.80 and 2.00, may sometimes be raised to 2.00 and 2.25, respectively.*

SPEC NOTE: The offest limit method presupposes that the slope of the pile taken as a free-stranding column (pile elastic line) is correctly determined. This slope is simple to determine for steel piles, but for concrete piles and concrete-filled pipe piles, the slope may be less accurately determined. The slope of the unloading portion of the load-movement curve may serve as an indication of the elastic line.

.2 The pile has failed the test if the movement of the pile head under an applied load of [VALUE] newton is larger than the movement at the offset limit according to Chapter 22 of the Canadian Foundation Engineering Manual (1985). The movement at the offset limit is equal to the calculated elastic column deformation of the pile, when loaded by the offset limit load, plus 4 mm plus 0.8 % of the pile face-to-face diameter.

.3 The pile has also failed the test if the load at plunging failure is smaller than [VALUE] newton.

.4 If the pile fails the test, carry out additional loading tests on additional piles as directed by [Engineer].

PART 1--GENERAL

1.1 Related Work

.1 [ ] [ ]

1.2 Shop Drawings

.1 Submit shop drawings in accordance with Section [ ].

.2 Submit shop drawings on the following items:

.1 [pile splice] [pile shoe] [pile head protection].

.2 [ ]

1.3 Protection

.1 Avoid damaging pile by bruising or breaking of wood fibres.

.2 Avoid breaking surface of treated piles.

.3 Do not damage surface of treated piles below cutoff elevation by boring holes or driving nails or spikes into them to support temporary material or staging. Support staging in rope slings carried over the upper end of piles or by attaching to pile clamps of approved design.

.4 Treat cuts, breaks, or abrasions on surface of treated piles, bolt holes and field cuts in accordance with CSA 080-M1983.

1.4 Method of measurement

SPEC NOTE: Select method-of-measurement clause(s) applicable. Ensure that unit prices for additions and are properly covered in contract documents.

SPEC NOTE: Delete 1.4.3 when using 1.4.1 and 1.4.2. Delete 1.4.1 and 1.4.2 when using 1.4.3.

.1 Supply of [pile] [pile segments] will be measured in length incorporated into the work.

SPEC NOTE: It may be necessary to clarify whether test piles for loading test are included with piles "for testing purposes" in 1.4.2.

.2 Installation of piles will be measured in number of piles driven and accepted [including those for testing purposes].

.3 Supply and installation of piles will be measured in total length of piles accepted and incorporated into work.

.4 [Pile toe reinforcement] [pile shoes] [pile splices] [pile head protection] [straps] are incidental to the supply and installation of the piles.

.5 Preservative treatment is incidental to the supply and installation of piles.

.6 Mobilization and demobilization costs for all equipment [are incidental to the supply and installation of the piles and will not be measured separately] [will be measured separately].

PART 2 - PRODUCTS

2.1 Materials

SPEC NOTE: For 2.1, require material specifications and properties suitable for type of application. Consider field conditions and environmental factors.

.1 Round wood pile to be in accordance with CAN3-056-M79 for clean peeled piles with minimum butt size of [ ] mm and diameter of tree top (pile toe) related to length as indicated in Table A-1. Order-length of piles to be [as indicated] [LENGTH] metre.

.2 Pile caps and brace timber to be [as indicated].

SPEC NOTE: For marine piles, specific reference may be made to CSA 080.18 in Clause 2.1.3. Limit treatment to one specific type of preservative.

.3 Preservative treatment to be in accordance with CSA 080-M1983.

.4 [Engineer] will be sole judge of quality and dimensions of piles. Remove rejected piles from site of work.

2.2 Miscellaneous Material

.1 Wire nails, spikes, and staples to be in accordance with CSA B111-1974.

.2 Bolts, nuts, and washers to be in accordance with ASTM A307-82a.

.3 Do not use items fabricated from scrap steel of unknown chemical composition or physical properties.

.4 Hot-dip galvanized bolts, nuts, and washers and, unless otherwise specified, staples, cable clamps, pipe sleeves, spikes, and nails to be in accordance with CSA G164-M1981 [ASTM A153-82]. Other galvanized hardware to be in accordance with ASTM A123-78.

PART 3 - EXECUTION

3.1 Preparation

.1 Select piles in each bent of a pile trestle for uniformity of size and straightness to facilitate placing of brace timbers.

.2 Protect pile toe as indicated.

.3 Protect pile head as indicated.

.4 Protect pile by means of steel straps placed no more than [ ] m apart along the length of pile with at least two straps placed within [500] mm of butt. Steel strapping and clip joints to develop a tensile strength of at least [22] kN and to be appoved by [Engineer].

3.2 Installation

.1 Install piles in accordance with Section [02351].

.2 Keep the pile driving helmet concentric and square with the pile head at all times and the leads in alignment with the pile. Occasionally during the driving, and whenever requested by [Engineer], lift off (lighten) helmet from pile to verify that the helmet and leads are not inducing bending stresses into the pile.

.3 Treat exposed ends of cut-off pile with [two] liberally brushed coats of hot creosote followed by an application of coal tar pitch, allowing sufficient interval between applications to permit absortion.

.4 Partially drive into the exposed end of cut-off pile a 500 mm deep metal ring 50 mm smaller in diameter than the pile. Fill ring with creosote and allow to soak into pile.

.5 Where indicated, install metal pile cover on pile heads immediately after treatment. Bend edges of cover down over side of pile, neatly trim, and fasten with [8] large head roofing nails.

3.3 Pile Caps

.1 Supply and install [timber] pile caps as indicated.

.2 Secure timber-to-timber splice with [NUMBER] [ ] mm diameter bolts, complete with steel plate washers.

.3 Connect timber to pile with [ ] mm diameter drift pin, [ ] mm in length.

.4 Treat ends of timber in accordance with Clause 3.2.3.

3.4 Bracing

.1 Supply and install bracing as indicated.

.2 Supply wood bracing of [ ]x[ ] [pressure treated] timber secured to each pile that is intersected by the bracing with [ ] diameter machine bolts complete with [ ] washers.

.3 Do not trim or cut piling to facilitate framing or bracing. Where necessary, install filler blocks between pile and brace to establish bracing in true plane.

PART 1--GENERAL

1.1 Related Work

.1 [ ] [ ]

1.2 Test Reports

.1 Prior to fabrication, provide [Engineer] with [two] copies of steel producer's certificates in accordance with [ASTM A252-82] [API 5L- 75] [AP1 5LS-75].

.2 One Charpy V-notch test is required per heat batch with results reported to [Engineer] by manufacturer.

1.3 Method of Measurement

SPEC NOTE: Select method-of-measurement clause(s) applicable. Ensure that unit prices for additions and deletions are properly covered in contract documents.

SPEC NOTE: Delete 1.3.3 when using 1.3.1 and 1.3.2. Delete 1.3.1 and 1.3.2 when using 1.3.3.

.1 Supply of steel pipe pile will be measured in [length] [weight] of piling material incorporated into the work. To allow for cut-off, a length of 0.5 metre per pipe pile will be added to the quantity of material incorporated into the work.

SPEC NOTE: It may be necessary to clarify whether test piles for loading test are included with piles "for testing purposes" in 1.3.2.

.2 Installation of piles will be measured in number of piles driven and accepted [including those for testing purposes].

.3 Supply and installation of piles will be measured in total length of piles accepted and incorporated into the work.

.4 [Pile toe reinforcement] [pile shoes] [pile splices] [pile caps] are incidental to the supply and installation of the steel pipe piles and will not be separately measured.

.5 Mobilization and de-mobilization costs for all equipment [will be measured separately] [are incidental to the supply and installation of steel pipe piles and will not be measured separately].

.6 Removal of material from interior of pipe piles and cleaning out is incidental to the supply and installation of the steel pipe piles and will not be measured separately.

.7 Drilling of sockets will be measured in [accumulated lengths from bottom of steel pipe to bottom of socket] [number of sockets drilled].

SPEC NOTE: Clauses 1.3.8 through 1.3.11 pertain to anchor piles only.

.8 Cleaning out of socket and inspection of socket are incidental to work and will not be measured separately.

.9 Supply and installation of steel anchors will be measured by the unit incorporated into the work.

.10 Grouting and concreting work and material [are incidental to work and will not be measured separately] [will be measured in volume of grout and volume of concrete placed and incorporated into the work].

.11 Pipe pile anchors including drilling, cleaning, grouting, and concreting will be measured [per unit] [per length of anchor] incorporated into work.

PART 2 - PRODUCTS

2.1 Materials

SPEC NOTE: For 2.1, require material specifications and properties suitable for type of application. Consider field conditions and environmental factors. Limit special requirements, properties, and tests, e. g. API, to actual job needs.

SPEC NOTE: Requirement of yield strength is important for both designed structural strength and for piles which require full-strength, butt-welded splices.

.1 Material of pipe pile to be [seamless] [welded] [straight longitudinal seam] [spiral butt] [spiral lapped] pipe of size and wall thickness indicated on [ ], with [plain] [bevelled] [flame] [machine] cut ends. Material to be in accordance with [API 5L-75] [API 5LS-75] [ASTM A252-82] Grade [2], and yield strength of [ ] MPa.

SPEC NOTE: Clause 2.1.2 is included to ensure that the pipe material will be weldable.

.2 Pipe material to have a chemical composition according to [CSA Z245.1-M1982].

.3 Pipe to have the following tolerances:

.3.1 The deviation from straight line, specified diameter, wall thickness, weight, and roundness on body of pipe and at pipe ends to conform to [API 5L-75] [API 5LS-75]. Pipe to be checked for deviations before leaving mill.

.3.2 The maximum curvature of a pipe measured along two perpendicular planes before driving, when pipe is not subjected to bending forces, shall not exceed 3 mm over any 3,000 mm length (0.1 %). (Curvature measurements of pipe are taken along a vertical plane and turning pipe 90 degrees between the two series of measurement).

.3.4 Deliver pipes in [ ], [ ], and [ ] metre [double random] lengths [as indicated].

.5 Material for pile toe reinforcement to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

.6 Material for pile splices to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

.7 Pile driving shoe to be in accordance with [CAN3-G40.21-M81 Grade [ ]], as manufactured by [ ].

.8 Pile splices to be in accordance with [CAN3-G40.21-M81 Grade [ ]], as manufactured by [ ] or approved equivalent.

.9 Material for pile shear ring to be in accordance with [CAN3-G40.21 M81 Grade [ ].

.10 Pile caps to be in accordance with [CAN3-G40.21-M81 Grade [ ].

.11 Welding electrodes to be in accordance with CSA W48 Series [ ].

SPEC NOTE: Clause 2.1.12; Coal tar epoxy does not normally require undercoating.

.12 For exterior protective coating, use [coal tar epoxy in accordance with CGSB 1-GP-184Ma], [inorganic zinc in accordance with CGSB 1-GP-171M+Amdt-Sep-82, Type I or II]. [Select coatings from suppliers listed in Government of Canada Qualified Products Lists].
.13 Concrete to be in accordance with Section [number].

.14 Reinforcing steel to be in accordance with Section [ ], sizes and details as indicated.

2.2 Fabrication

.1 Fabricate full length piles to eliminate splicing during during installation wherever possible.

.2 Driving shoes may be installed during shop fabrication or as part of field work.

.3 Full length piles may be fabricated from piling material [[before] [or] [during] installation] by splicing lengths of pipe together. Use [complete joint penetration groove welds] [premanufactured splice sleeves as indicated].

SPEC NOTE: Coordinate Clause 2.2.4 with 1.3 Method of Measurement.

.4 Submit details of planned use of pile material stock to [Engineer] for approval prior to start of fabrication. Re-use cut-off lengths as directed by [Engineer].

SPEC NOTE: Do not require back-up ring unless necessary, as the ring may interfere with the probe for inspection of excessive bending. See Section 02351.

.5 Install [pile toe reinforcement] [splices] [driving shoes] [and] [shear rings] as indicated.

.6 The deviation of the pile from a straight line [after splicing] shall not exceed 15 mm as as measured over a length of 3,000 mm (0.5 %).

.7 Weld in accordance with [CSA W59 M1982] [Section [ ]].

.8 Welding certification of Contractor to be in accordance CSA W47.1-1983.

.9 Repair defective welds only on authority of [Engineer]. Weld that shows evidence of having been repaired without authorization may be rejected. When authorized, make repairs in accordance with CSA W59-1982.

.10 Repair damaged exterior protective coating of piles as specified in [3.1.10].

2.3 Painting, Coating

SPEC NOTE: Delete 2.3 when painting or pre-painting and treatment is not required. If other systems are required, modify to suit.

.1 Painting requirements include surface preparation of outer surfaces of piling [including pile caps] by grit blasting, application of inorganic zinc coating and coal-tar epoxy coating, and touch-up after delivery if necessary.

.2 Do not paint portions of pile which are to be encased in concrete.

SPEC NOTE: For 2.3.3, identify pipe by diameter and wall thickness and give length of pile.

.3 Paint pile [diameter, wall] over [length only] [complete] length.

.4 Paint piles from 500 mm below finished ground elevation or from low water level to top of exposed steel.

.5 Surface Preparation:

.5.1 Sand or grit blast in accordance with [CGSB 31-GP404a, Method 3, Commercial Blast Cleaning using sand to CGSB 31-GP421M, Type 1 or Type 2] [SSPC-SP2, SP3, SP4, SP5, SP6, SP7, SP8, SP9, SP10].

.5.2 When sand or grit blasting is completed, remove dust by brushing or vacuuming prior to painting.

.5.3 Prior to painting remove oil, grease, or organic matter with solvents or detergents approved by [Engineer].

.5.4 Apply first coat of paint [on same day as] [within one hour of] sand or grit blasting [is completed].

.6 Application:

.6.1 Apply [two] [three] coats of paint, each in accordance with the manufacturer's recommendation.

.6.2 For first coat of paint, use inorganic zinc and apply to a dry-film thickness of average 75 micrometre and minimum 65 micrometre.

.6.3 For second and third coats, use coal tar epoxy and apply to an average single coat dry-film thickness of 180 micrometre.

.6.4 Coats to be free of sags and runs.

.7 Touch up scratched or uncoated surfaces with two applications of coal tar epoxy, where necessary, before and after driving.

PART 3 - EXECUTION

3.1 Installation

SPEC NOTE: For pipes installed by driving, when wall thickness and yield strength of pipe are specified, make sure that the section specified can resist all driving stresses. See Section 02351.

.1 Install piles in accordance with Section [02351].

SPEC NOTE: Do not require back-up ring unless necessary, as the ring may interfere with the mandrel probe for inspection of excessive bending. See Section 02351. A back-up ring is normally not needed if the pile wall is thicker than 7 mm.

.2 If permitted, splice piles in place during installation by welding. To prevent distortion, tack weld first and complete welding of opposite points. [For pipe walls thinner than 7 mm, weld against a back-up ring]. Make splice [by complete joint operation groove weld] [as indicated on [ ]].

.3 If permitted, splice piles in place during installation by means of premanufactured splicing units as manufactured by [ ]. Weld splice to lower segment before lifting and driving segment.

.4 Hold pipe segments carefully in alignment during the splicing operation to ensure meeting tolerances as specified in Clause [ ].

SPEC NOTE: 3.1.5 refers to long pipe piles driven closed-toe. 3.1.6 and 3.1.7 refer to pipe pile driven open-toe.

.5 After driving, and occasionally during the driving as requested by [Engineer], inspect pile for excessive bending by means of lowering the mandrel probe specified in Section [02351].

.6 Suspect piles, as identified by [Engineer], to be cleaned out after driving by removing all soil and debris from inside the pipe and inspected by means of inspection probe as specified in Section 02[351]. Pile to be restruck after cleaning and inspection and driven to penetration resistance specified by [Engineer].

.7 Advance pipe pile by alternatively driving and cleaning out pile by drilling and excavating soil from inside the pipe. Churning ahead of the pile toe to ease penetration is permitted if made [ ] metre above final toe depth. Pile to be restruck after cleaning and driven to penetration resistance specified by [Engineer].

SPEC NOTE: 3.1.8 refers to large diameter concrete-filled pipe piles which enable a person to enter the pipe.

.8 Perform internal visual inspection of steel pipe, splices, and toe prior to placing of concrete. Ensure that the inside of pipe is free from foreign matter.

3.2 Concreting

SPEC NOTE: For 3.2.1 through 3.2.12, omit clauses which are not applicable.

.1 Assemble and install reinforcement cages as indicated in [ ].

.2 Do not commence placement of concrete until pipe piles have been cleaned out and reinforcing cage has been installed.

.3 If more than six hours have elapsed since pile was cleaned-out, do not place concrete until pile has been cleaned-out again.

.4 Do not place concrete in anchor piles, where grout has been placed, until [72 hours] after completion of grouting operation.

SPEC NOTE: Clauses 3.2.5 through 3.2.9 refer to underwater concreting work.

.5 Provide a tremie pipe which is watertight and sufficiently large to enable free flow of concrete. The diameter of tremie pipe must not be smaller than 200 mm or smaller than eight times maximum size of the coarse aggregate in the concrete.

.6 Provide a hopper at top of tremie pipe and means to raise and lower tremie pipe.

.7 Provide plug or foot valve at end of tremie pipe to enable initial, complete filling of tremie pipe with concrete.

.8 Start pour with tremie pipe full of concrete and keep end of tremie pipe buried at least 300 mm into freshly placed concrete. Control rate of flow by increasing or decreasing depth of end of tremie pipe ensuring that the end does not lift above the surface of the concrete.

.9 If concrete is pumped, follow procedures similar to tremie method of placing concrete using discharge line from concrete pump as tremie pipe.

SPEC NOTE: Clauses 3.2.10 and 3.2.11 refer to placing concrete when pipe is dry or dewatered.

.10 Install concrete in accordance with Section [ ].

.11 Fill steel pipe pile with concrete using methods to limit free fall and to prevent segregation. Ensure adequate vibration to completely fill cross section of pipe.

.12 Set dowels in concrete in acordance with details indicated on [ ]. Secure until concrete is set.

3.3 Pipe Pile Anchors

.1 After advancing pipe pile to toe elevation or penetration indicated, clean out pipe by removing all soil and debris from inside of pipe to toe of pipe pile.

.2 Drill socket for anchor pile beyond toe of pipe pile as indicated.

.3 After socket has been drilled, thoroughly clean out inside surface of socket and pipe by air-lifting.

.4 Do not install reinforcing cage in pile and socket until [Engineer's] inspection is complete.

.5 Use spacers for centering [reinforcing cage] [and] [steel anchoring] in pile and socket.

.6 If more than six hours have elapsed since final cleaning of socket and pile, do not commence grouting until pile and socket have been inspected and, if necessary, cleaned out again.

.7 Inject grout at the lowest point in the socket.

.8 Place grout in one continous operation to completely fill socket and pile to the level indicated with a dense homogeneous mass of grout, free from voids.

.9 Secure and maintain pipe pile in proper position so that the pipe does not move during grouting and during curing of grout to specified strength.

3.4 Welding

.1 Weld in accordance with CSA W59-1982.

.2 Welding certification of Contractor to be in accordance with CSA W47.1-1983.

PART 1--GENERAL

1.1 Related Work

.1 [ ] [ ]

.2 Test Report

.1 Prior to fabrication, provide [Engineer] with [two] copies of steel producer's certificates in accordance with [ASTM A245] and mill test reports according to [CAN3-G40.20-M81] [SA S16-1969] [CAN3S16.1-M78] [CAN3-S16.1M1981].

1.3 Delivery and Storage

.1 During delivery, storage, and handling, support long piles with webs in vertical position.

1.4 Method of Measurement

SPEC NOTE: Select applicable method-of-measurement clause(s). Ensure that unit prices for additions and deletions are properly covered in contract documents.

SPEC NOTE: Delete 1.4.3 when using 1.4.1 and 1.4.2. Delete 1.4.1 and 1.4.2 when using 1.4.3.

.1 Supply of steel H pile will be measured in [length] [weight] of piling material incorporated into the work. To allow for cut-off, a length of 0.5 metre per H-pile will be added to the quantity of material incorporated into the work.

SPEC NOTE: It may be necessary to clarify whether test piles for loading test are included with piles "for testing purposes" in 1.4.2.

.2 Installation of piles will be measured in number of piles driven and accepted [including those for testing purposes].

.3 Supply and installation of H-piles will be measured in total length of piles accepted and incorporated into work.

.4 [Pile toe reinforcement] [pile shoes] [pile splices] [pile caps] are incidental to the supply and installation of the piles and will not be separately measured.

.5 Mobilization and de-mobilization of and costs for all equipment [are incidental to the supply and installation of the steel H piles and will not be measured separately] [will be measured separately].

PART 2 - PRODUCTS

2.1 Materials

SPEC NOTE: For 2.1, require material specifications and properties suitable for type of application. Consider field conditions and environmental factors. Limit special requirements, properties, and tests, e. g. API, to actual job needs.

SPEC NOTE: Requirement of yield strength is important for both designed structural strength and for piles which require full-strength, butt-welded splices.

.1 Steel H pile material to be in accordance with [CAN3-G40.20-M81 and CAN3-G40.21-M81], Grade [300 W] [350W] [350T].

.2 Size and weight of H-pile to be as indicated.

.3 Steel plates to be in accordance with [CAN3-G40.20-M81 and CAN3-G40.21-M81], Grade [300 W] [350W] [300WT].

.4 Steel H pile to have the following tolerances:

.4.1 The maximum curvature of an H pile measured along two perpendicular planes before driving, when the beam is not subjected to bending forces, must not exceed 3 mm over any 3000 mm length (0.1 %). (Curvature measurements are taken along a vertical plane and turning the pile 90 degrees between the two series of measurement).

.5 Deliver H pile in lengths as indicated.

.6 Pile toe reinforcement to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

.7 Pile splices to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

SPEC NOTE: In Clauses 2.1.10 and 2.1.11, identify type, size, and acceptable manufacturers.

.10 Pile driving shoe to be in accordance with [CAN3-G40.21-M81 Grade [ ]], as manufactured by [ ] or approved equivalent.

.11 Premanufactured pile splices to be in accordance with [CAN3-G40.21-M81 Grade [ ]], as manufactured by [ ] or approved equivalent.

.12 Pile caps to be in accordance with [CAN3-G40.21-M81, Grade [ ].

.13 Welding electrodes to be in accordance with CSA W48[.1M1980].

SPEC NOTE: Clause 2.1.14; Coal tar epoxy does not normally require undercoating.

.14 For exterior protective coating, use [coal] tar Epoxy in accordance with CGSB 1-GP-184Ma], [inorganic zinc in accordance with CGSB 1-GP-171M+Amdt-Sep-82, Type I or II]. [Select coatings from suppliers listed in Government of Canada Qualified Products Lists].

2.2 Fabrication

.1 Fabricate full length piles to eliminate splicing during installation wherever possible.

.2 Driving shoes may be installed during shop fabrication or as part of field work.

.3 Full length piles may be fabricated from piling material by splicing lengths of H-pile together. Use [complete joint penetration groove welds] [premanufactured splice as indicated].

.3 Prepare surfaces to be spliced by cutting and grinding square to ensure full bearing of H-beam ends.

.4 Splice pile extensions to details indicated on [approved] [reviewed] shop drawings by using [splice plates] [bar splices] [butt-welded splices] [premanufactured splices].

.5 The deviation of the pile from a straight line [after splicing] shall not exceed 15 mm (0.5 %) as measured over a length of 3000 mm.

SPEC NOTE: Coordinate 2.2.6 with 1.3 Method of Measurement.

.6 Submit details of planned use of pile material stock to [Engineer] for approval prior to start of fabrication. Re-use cut-off lengths as directed by [Engineer].

.7 Install [pile toe reinforcement] [driving shoes] as indicated on [ ].

.8 Weld in accordance with CSA W59-1982.

.9 Welding certification of Contractor to be in accordance with CSA W47.1-1983.

.10 Repair defective welds only on authority of [Engineer]. Weld which shows evidence of having been repaired without authorization may be rejected. When authorized, make repairs in accordance with CSA W59-1982.

.11 Repair damaged exterior protective coating of piles as specified in [3.1.10].

2.3 Painting and coating

SPEC NOTE: Delete 2.3 when painting or pre-painting treatment is not required. If other systems are required, to suit.

.1 Painting requirements include surface preparation of outer surfaces of piling [including pile caps] by grit blasting, application of inorganic zinc coating and coal-tar epoxy coating, and touch-up after delivery if necessary.

.2 Do not paint portions of pile that are to be encased in concrete.

SPEC NOTE: For 2.3.3, identify pile by weight, diameter, and wall thickness and give length of pile.

.3 Paint pile [weight, diameter, wall] over [length only] [complete] length.

.4 Paint piles from 500 mm below finished ground elevation or from low water level to top of exposed steel.

.5 Surface Preparation:

.5.1 Sand or grit blast in accordance with [CGSB 31-GP404a, Method 3, Commercial Blast Cleaning using sand to CGSB 31-GP421M, Type 1 or Type 2] [SSPC-SP2, SP3, SP4, SP5, SP6, SP7, SP8, SP9, SP10].

.5.2 When sand or grit blasting is completed, remove dust by brushing or vacuuming prior to painting.

.5.3 Prior to painting remove oil, grease, or organic matter with solvents or detergents approved by [Engineer].

.5.4 Apply first coat of paint [on same day as] [within one hour of] sand or grit blasting [is completed].

.6 Application:

.6.1 Apply [two] [three] coats of paint, each in accordance with the manufacturer's recommendation.

.6.2 For first coat of paint, use inorganic zinc and apply to a dry-film thickness of average 75 micrometer and minimum 65 micrometer.

.6.3 For second and third coats, use coal tar epoxy and apply to an average single coat dry-film thickness of 180 micrometer.

.6.4 Coats to be free of sags and runs.

.7 Touch up scratched or uncoated surfaces with two applications of coal tar epoxy, where necessary, before and after driving.

PART 3 - EXECUTION

3.1 Installation

.1 Install piles in accordance with Section [02351].

.2 If permitted, splice piles in place during installation by welding. To prevent distortion, tack weld first and complete welding of opposite points. Make splice [by complete joint operation groove weld] [as indicated on [ ]].

.3 If permitted, splice piles in place during installation by means of premanufactured splices as manufactured by [ ].

.4 Hold pile segments carefully in alignment during splicing operation to ensure meeting tolerances as specified in Clause [ ].

3.2 Welding

.1 Weld in accordance with CSA W59-1982.

.2 Welding certification of Contractor to be in accordance with CSA W47.1-1983.

PART 1--GENERAL

1.1 Related Work

.1 [ ] [ ]

.2 Test Report

.1 Prior to fabrication, provide [Engineer] with [two] copies of steel producer's certificates in accordance with [ASTM A245] and mill test reports according to [CAN3-G40.20-M81] [SA S16-1969] [CAN3S16.1-M78] [CAN3-S16.1M1981].

1.3 Delivery and Storage

.1 During delivery, storage, and handling, support long piles with webs in vertical position.

1.4 Method of Measurement

SPEC NOTE: Select applicable method-of-measurement clause(s). Ensure that unit prices for additions and deletions are properly covered in contract documents.

SPEC NOTE: Delete 1.4.3 when using 1.4.1 and 1.4.2. Delete 1.4.1 and 1.4.2 when using 1.4.3.

.1 Supply of steel H pile will be measured in [length] [weight] of piling material incorporated into the work. To allow for cut-off, a length of 0.5 metre per H-pile will be added to the quantity of material incorporated into the work.

SPEC NOTE: It may be necessary to clarify whether test piles for loading test are included with piles "for testing purposes" in 1.4.2.

.2 Installation of piles will be measured in number of piles driven and accepted [including those for testing purposes].

.3 Supply and installation of H-piles will be measured in total length of piles accepted and incorporated into work.

.4 [Pile toe reinforcement] [pile shoes] [pile splices] [pile caps] are incidental to the supply and installation of the piles and will not be separately measured.

.5 Mobilization and de-mobilization of and costs for all equipment [are incidental to the supply and installation of the steel H piles and will not be measured separately] [will be measured separately].

PART 2 - PRODUCTS

2.1 Materials

SPEC NOTE: For 2.1, require material specifications and properties suitable for type of application. Consider field conditions and environmental factors. Limit special requirements, properties, and tests, e. g. API, to actual job needs.

SPEC NOTE: Requirement of yield strength is important for both designed structural strength and for piles which require full-strength, butt-welded splices.

.1 Steel H pile material to be in accordance with [CAN3-G40.20-M81 and CAN3-G40.21-M81], Grade [300 W] [350W] [350T].

.2 Size and weight of H-pile to be as indicated.

.3 Steel plates to be in accordance with [CAN3-G40.20-M81 and CAN3-G40.21-M81], Grade [300 W] [350W] [300WT].

.4 Steel H pile to have the following tolerances:

.4.1 The maximum curvature of an H pile measured along two perpendicular planes before driving, when the beam is not subjected to bending forces, must not exceed 3 mm over any 3000 mm length (0.1 %). (Curvature measurements are taken along a vertical plane and turning the pile 90 degrees between the two series of measurement).

.5 Deliver H pile in lengths as indicated.

.6 Pile toe reinforcement to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

.7 Pile splices to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

SPEC NOTE: In Clauses 2.1.10 and 2.1.11, identify type, size, and acceptable manufacturers.

.10 Pile driving shoe to be in accordance with [CAN3-G40.21-M81 Grade [ ]], as manufactured by [ ] or approved equivalent.

.11 Premanufactured pile splices to be in accordance with [CAN3-G40.21-M81 Grade [ ]], as manufactured by [ ] or approved equivalent.

.12 Pile caps to be in accordance with [CAN3-G40.21-M81, Grade [ ].

.13 Welding electrodes to be in accordance with CSA W48[.1M1980].

SPEC NOTE: Clause 2.1.14; Coal tar epoxy does not normally require undercoating.

.14 For exterior protective coating, use [coal] tar Epoxy in accordance with CGSB 1-GP-184Ma], [inorganic zinc in accordance with CGSB 1-GP-171M+Amdt-Sep-82, Type I or II]. [Select coatings from suppliers listed in Government of Canada Qualified Products Lists].

2.2 Fabrication

.1 Fabricate full length piles to eliminate splicing during installation wherever possible.

.2 Driving shoes may be installed during shop fabrication or as part of field work.

.3 Full length piles may be fabricated from piling material by splicing lengths of H-pile together. Use [complete joint penetration groove welds] [premanufactured splice as indicated].

.3 Prepare surfaces to be spliced by cutting and grinding square to ensure full bearing of H-beam ends.

.4 Splice pile extensions to details indicated on [approved] [reviewed] shop drawings by using [splice plates] [bar splices] [butt-welded splices] [premanufactured splices].

.5 The deviation of the pile from a straight line [after splicing] shall not exceed 15 mm (0.5 %) as measured over a length of 3000 mm.

SPEC NOTE: Coordinate 2.2.6 with 1.3 Method of Measurement.

.6 Submit details of planned use of pile material stock to [Engineer] for approval prior to start of fabrication. Re-use cut-off lengths as directed by [Engineer].

.7 Install [pile toe reinforcement] [driving shoes] as indicated on [ ].

.8 Weld in accordance with CSA W59-1982.

.9 Welding certification of Contractor to be in accordance with CSA W47.1-1983.

.10 Repair defective welds only on authority of [Engineer]. Weld which shows evidence of having been repaired without authorization may be rejected. When authorized, make repairs in accordance with CSA W59-1982.

.11 Repair damaged exterior protective coating of piles as specified in [3.1.10].

2.3 Painting and coating

SPEC NOTE: Delete 2.3 when painting or pre-painting treatment is not required. If other systems are required, to suit.

.1 Painting requirements include surface preparation of outer surfaces of piling [including pile caps] by grit blasting, application of inorganic zinc coating and coal-tar epoxy coating, and touch-up after delivery if necessary.

.2 Do not paint portions of pile that are to be encased in concrete.

SPEC NOTE: For 2.3.3, identify pile by weight, diameter, and wall thickness and give length of pile.

.3 Paint pile [weight, diameter, wall] over [length only] [complete] length.

.4 Paint piles from 500 mm below finished ground elevation or from low water level to top of exposed steel.

.5 Surface Preparation:

.5.1 Sand or grit blast in accordance with [CGSB 31-GP404a, Method 3, Commercial Blast Cleaning using sand to CGSB 31-GP421M, Type 1 or Type 2] [SSPC-SP2, SP3, SP4, SP5, SP6, SP7, SP8, SP9, SP10].

.5.2 When sand or grit blasting is completed, remove dust by brushing or vacuuming prior to painting.

.5.3 Prior to painting remove oil, grease, or organic matter with solvents or detergents approved by [Engineer].

.5.4 Apply first coat of paint [on same day as] [within one hour of] sand or grit blasting [is completed].

.6 Application:

.6.1 Apply [two] [three] coats of paint, each in accordance with the manufacturer's recommendation.

.6.2 For first coat of paint, use inorganic zinc and apply to a dry-film thickness of average 75 micrometer and minimum 65 micrometer.

.6.3 For second and third coats, use coal tar epoxy and apply to an average single coat dry-film thickness of 180 micrometer.

.6.4 Coats to be free of sags and runs.

.7 Touch up scratched or uncoated surfaces with two applications of coal tar epoxy, where necessary, before and after driving.

PART 3 - EXECUTION

3.1 Installation

.1 Install piles in accordance with Section [02351].

.2 If permitted, splice piles in place during installation by welding. To prevent distortion, tack weld first and complete welding of opposite points. Make splice [by complete joint operation groove weld] [as indicated on [ ]].

.3 If permitted, splice piles in place during installation by means of premanufactured splices as manufactured by [ ].

.4 Hold pile segments carefully in alignment during splicing operation to ensure meeting tolerances as specified in Clause [ ].

3.2 Welding

.1 Weld in accordance with CSA W59-1982.

.2 Welding certification of Contractor to be in accordance with CSA W47.1-1983.

PART 1 - GENERAL

1.1 Related Work

.1 [ ] [ ]

1.2 Shop Drawings

.1 Submit shop drawings in accordance with Section [ ].

.2 Include shop drawings on the following items:

.2.1 [Pile, including details on reinforcement] [pile splice] [pile shoe] [pile head protection]

.2.2 [ ]

.2.3 [ ]

.3 Submit information on pile head protection for [approval] [review].

.4 Submit information on pile cushion for [approval] [review].

1.3 Delivery and storage

.1 Provide identification for points of lifting by painted stripes or lift hooks cast in pile.

.2 Provide identification for points of support for storage.

1.4 Method of Measurement

SPEC NOTE: Select method-of-measurement clause(s) applicable. Ensure that unit prices for additions and deletions are properly covered in contract documents.

SPEC NOTE: Delete 1.4.3 when using 1.4.1 and 1.4.2. Delete 1.4.1 and 1.4.2 when using 1.4.3.

.1 Supply of [pile] [pile segments] will be measured in length incorporated into the work.

SPEC NOTE: It may be necessary to clarify whether test piles for loading test are included with piles "for testing purposes" in 1.4.2.

.2 Installation of piles will be measured in number of piles driven and accepted [including those for testing purposes].

.3 Supply and installation of piles will be measured in total length of piles accepted and incorporated into work.

.4 [Pile toe reinforcement] [pile shoes] [pile splices] [pile head protection] are incidental to the supply and installation of the piles.

.5 Mobilization and de-mobilization costs for all equipment [are incidental to the supply and installation of the piles and will not be measured separately] [will be measured separately].

PART 2 - PRODUCTS

2.1 Materials

SPEC NOTE: For 2.1, require material specifications properties suitable for type of application. Consider conditions and environmental factors.

.1 Concrete for pile to be in accordance with Section 03[and have a 28-day strength not smaller than [50] MPa.

.2 Reinforcing steel to be in accordance with Section 03[ ], sizes and details as indicated.

.3 Prestressing steel to be in accordance with [ASTM A416-80, uncoated seven-wire stress-relieved strand Grade [270]] [ASTM A421-80, uncoated stress-relieved wire with minimum yield strength of [ ] MPa] [CSA G279-M1982 steel for prestressed concrete tendons].

.4 Welded wire mesh to be in accordance with CSA G30.5-M1983.

.5 Spiral reinforcement to be in accordance with CSAG30.5-M1983, cold-drawn steel wire.

SPEC NOTE: Prestressed piles longer than about 25 metre should usually be designed to include a center tube for inspection of pile for potential bending, dog-legging, and integrity.

SPEC NOTE: Center tubes made from plastic pipes are difficult to cast in good alignment with the pile. Due to that their thermal expansion is much larger than that of concrete, they expand during the curing of the concrete and this may create cracks in the pile and develop discontinuities between lengths of plastic pipes.

.6 Provide center tube made of steel and in accordance with ASTM A120-84 of O.D. [48.3] mm, Schedule 40. Center tube made of plastic is not acceptable.

.7 Splice center tube with outside couplings ensuring that inside of tube is straight and smooth across the tube splice.

.8 Deliver pile [segment] in [ ] and [ ] m lengths as indicated.

.9 Material for pile driving shoe to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

.10 Material for pile splices to be in accordance with [CAN3-G40.21-M81 Grade [ ]].

SPEC NOTE: In Clauses 2.1.11 and 2.1.12, identify type, size, and acceptable manufacturers.

SPEC NOTE: Spliced precast piles should be designed to include a center tube. Therefore, the splices must be designed for centering, aligning, and passing the center tube through the splice. A pile driving shoe should be included and designed to receive and center the center tube at the toe of the pile.

.11 Pile splice to be manufactured entirely from steel plates which have been machined to ensure plane surfaces and cast into the segment end by means of reinforcing bars and be as manufactured by [ ], Type and size as indicated. If a center tube is cast in the pile, the splice shall be equipped with a suitable o-ring sealing arrangement to prevent soil and water from entering the tube through the splice.

.12 Pile shoe to be manufactured entirely from steel plates, [equipped with a loose, hardened rock point,] and cast into the segment end by means of reinforcing bars and be as manufactured by [ ].

.13 Pile toe protection to be as indicated or to consist of part of splice.

.14 Pile head protection to be as indicated or to consist of part of splice.

2.2 Fabrication

.1 Fabricate full length piles to minimize splicing installation [wherever possible].

.2 Fabricate pile [segments] with longitudinal and spiral reinforcement [and center tubes] placed, as indicated.

.3 Fabricate piles to the following tolerances:

.3.1 Length: 30 mm

.3.2 Diameter: -6 mm to +12 mm

.3.3 Wall of hollow section: -6 to +10 mm

.3.4 Deviation of internal hollow or void from specified position: 10 mm

.3.5 Out-of-squareness of pile [segment] ends: 1 %

.3.6 Location of main reinforcing steel: [5] mm

.3.7 Location of prestressing strands: [5] mm

.3.8 Location of spiral reinforcement: [5] mm

.3.9 Location of center tube: [5] mm

.3.10 Maximum deviation of the center tube from a straight line in any plane in the casting bed before the concrete is placed: 3 mm over any length of 3.00 metre (0.1 %). Verify and document to [Engineer] that inspection probe as specified in Section [02351] can easily penetrate the full length of the center tube as soon as the pile [segment] has been removed from the casting bed.

.3.11 Maximum width, height, and depth of surface irregularity: 10 mm.

.3.12 The maximum curvature of a pile [segment] measured along two perpendicular planes before driving, when the pile [segment] is not subjected to bending forces: 15 mm over any 3.00 m length (0.5 %). (Take curvature measurements along a vertical plane turning the pile 90° between the two series of measurements).

.4 Full-length piles may be fabricated from piling material by splicing pile segments together using premanufactured mechanical splices as indicated in Clause [2.1.10].

SPEC NOTE: For prestressed concrete piles, the strand slippage governs the prestress transfer length. In case of a pile made up of segments which are spliced in the field, it is important that the pre-stress transfer length is shorter than the dowels connecting the splicing plates to the pile.

.5 Prestressed pile segments intended for splicing in the field to be checked for strand slippage at segment ends upon releasing strands and the measurements documented to [Engineer].

.6 On completion of driving, cut off piles squarely at required elevation[s].

SPEC NOTE: Usually, a portion of the longitudinal reinforcement is freed of concrete to serve as reinforcing connecting the pile head to the pile cap.

.7 After cut-off, free the longitudinal reinforcement [over a length of 0.6 metre] [above Elevation [+] m] [as indicated].

PART 3 - EXECUTION

3.1 Installation

.1 Install piles in accordance with Section 02351].

.2 Handle and store piling in such a manner no damage will be done to the material or work.

.3 Store piling on level ground and provide supports so that piling is level and straight when stored. Provide blocking at appropriate spacings so that there is no sagging and bending in piling. Block between lifts directly above blocking in lower lift.

.4 Piling that is suspected to be cracked and damaged [will] [may] be subjected to low-strain integrity testing before use. [Engineer] will be sole judge of acceptability of such piling.

.5 Use slings when lifting pile segments so that mass is evenly distributed and piling is not subjected to excessive bending stress.

SPEC NOTE: When driving concrete piles, tensile stresses developing during easy driving may become critical for the integrity of the pile.

.6 During easy driving, ensure that damaging tension stresses do not develop in the pile. Damaging tension stresses are stresses that exceed about 70 % of the yield strength of the longitudinal reinforcement with no allowance for the tensile strength of the concrete.

.7 During prolonged driving, ensure that damaging compression stresses do not develop in the pile. Damaging compression stresses are stresses that regularly exceed about 50 % of the concrete 28-day strength and, occasionally, exceed 70 %.

.8 [Engineer's] assessment of damaging driving stresses [will] [may] necessitate dynamic monitoring using the Pile Driving Analyzer, as described in Section 02351.

.9 [Engineer's] [will] [may] use the Pile Driving Analyzer (as described in Section 02351) or employ low-strain integrity testing to assess the integrity of driven piling.

.10 If permitted, splice piles in place during installation by means of premanufactured mechanical splices as indicated in Clause [2.1.10].

.11 Remove all of old pile cushion and place a new pile cushion into the helmet [before starting to drive a pile] [and] whenever during the driving there is an indication that the pile cushion has been excessively compressed, heated up, or damaged.

.12 Keep the pile driving helmet concentric and square with the pile head at all times and the leads in alignment with the pile. Occasionally during the driving, and whenever requested by [Engineer], lift off (lighten) helmet from pile to verify that the helmet and leads are not inducing bending stresses into the pile.

.13 After driving, or occasionally during the driving as requested by [Engineer], inspect pile for excessive curvature by means of lowering the inspection probe into the center tube as specified in Section [02351]. Inspection through the center tube may require prior cleaning out soil and dirt from the interior of the tube. Cleaning of the center tube is incidental to the piling work and will not be measured separately.

SPEC NOTE: The integrity of the completed shaft can be investigated by means of dynamic low-strain methods. Such measurements are best performed before the pile cap is poured.

.14 Do not prepare and pour pile cap before approval has been given by [Engineer].

PART 1 - GENERAL

1.1 Related Work

SPEC NOTE: Coordinate related sections and insert appropriate references.

.1 Excavations and Backfilling for Structures, Section HC02219.

.2 Pile Foundations, General, Section 02351

.3 Welding, Section 02364

.4 Concrete Reinforcement, Section HC03201

1.2 Test Reports

.1 Prior to fabrication, provide [Engineer] with [two] copies of steel producer's certificates in accordance [ASTM A245-82] and mill test reports according to [CAN3-G40.20-M81] [SA S16-1969] [CAN3S16.1-M78] [CAN3-S16.1M1981] for steel piling and tie rod anchors.

.2 Provide [Engineer] with copy of certification for fusion welding in accordance with CSA W47.1-1973.

1.3 Source Quality Control

.1 Provide results of tests of sheet piling material to be used on project as follows:

.1.1 One tension test and one bend test from each heat for amount of finished material smaller than [50] tonnes.

.1.2 Two tension tests and [two] bend tests from each heat for amount of finished material larger than [50] tonnes.

.2 For tension tests, provide results in accordance with CAN2-G40.20-M81

.3 For bend tests of Hot Rolled Steel Sheet Piling material to be used on project, provide results tests in accordance with ASTM A6-82a.

.4 For bend tests of Cold Formed Steel Sheet Piling material to be used on project, provide results as follows:

.4.1 S14-1 Bend tests shall be performed with material in condition as used in cold forming operation. Three tests shall be made from each heat and each thickness of material produced. Bend-test specimens shall be taken from edge of each coil. Longitudinal axis of specimen shall be transverse to coil rolling direction.

.4.2 S14.1.1 Except as provided below, bend-test specimens shall have a minimum width to thickness ratio of 8, with both edges parallel throughout section in which bending occurs and is maintained.

.4.3 S14.2 Minor surface separations shallower than 0.8 mm in depth related to superficial steel surface or subsurface discontinuities will not cause rejection. Surface separations in excess of 0.8 mm depth and/or cracks normal to metal surface will cause rejection.

1.4 Delivery, Handling and Storage

.1 Handle and store sheet piling material in such a manner no damage will be done to the material or work.

.2 Use slings for lifting piling so that mass is evenly distributed and piling is not subjected to excessive bending stress.

.3 Store sheet piling on level ground or provide supports so that sheet piling is level when stored. Provide blocking at a spacing not exceeding 5.0 metre so that there is no excessive sagging in piling. Overhang at sheet pile ends not to exceed 0.5 metre. Block between lifts directly above blocking in lower lift.

.4 If material is stock-piled on a structure, ensure that structure is not overloaded.

1.5 Quality Assurance

.1 Inspection and testing of steel sheet piling material may be carried out by testing laboratory designated by [Engineer] at any time during course of work.

.2 Materials inspected and tested by [Engineer] which fail to meet contract requirements will be rejected.

.3 Materials failing to meet contract requirements may be rejected at any time in course of work.

.4 Where tests or inspections by designated testing laboratory reveal work not in accordance with contract requirements, Contractor shall pay costs for additional tests or inspections as [Engineer] may require to verify acceptability of corrected work.

1.6 Shop Drawings

.1 Submit shop drawings in accordance with Section [ ] for the following items:

.1.1 [ ]

.1.2 [ ]

.1.3 [ ]

1.7 Method of Measurement

SPEC NOTE: Select method-of-measurement clause(s) applicable. Ensure that unit prices for additions and deletions are properly covered in contract documents.

SPEC NOTE: When supply is included with installation in Clause 1.7.2, delete Clause 1.7.1.

.1 Supply of steel sheet piling will be measured in area of piling authorized by [Engineer] and delivered to site. Area will be calculated by multiplying lengths of piles by widths. Width of a steel sheet pile section is defined as center-to-center distance between pile interlocks measured along a plane parallel to finished wall.

.2 [Supply and] installation of steel sheet piling will be measured in area of piling remaining in place after cut-off. Piling will be measured in plane of bulkhead, [calculated by multiplying straight, horizontal, center-line length of bulkhead measured at upper end of piles by average vertical length of piles installed and left in work]. [Elevation [+] will be taken as the elevation of the upper end of all piles].

.3 Splicing of piles will be measured by number of splices made when indicated or directed by [Engineer].

.4 Supply and installation of tie rods, sleeve nuts, turnbuckles, pipe sleeves, bearing plates, washers, transfer bolts, steel wales, and other associated hardware incorporated in work, as indicated, will be measured in weight.

.5 Toe pins and sleeves, including drilling and grouting of holes into rock, will be measured by number of pins placed.

.6 Drilling and blasting of toe trench will be measured in length.

.7 Backfill will be measured in [weight] [volume] of backfill placed to dimensions indicated and incorporated in completed work.

.8 [Pile toe reinforcement] [pile shoes] [pile caps] are incidental to the supply and installation of the piles and will not be separately measured.

.9 Mobilization and de-mobilization of and costs for all equipment [are incidental to the supply and installation of the steel sheet piling and will not be measured separately] [will be measured separately].

PART 2 - PRODUCTS

2.1 Materials

SPEC NOTE: For 2.1, require material specifications and properties suitable for type of application. Consider field conditions and environmental factors. Limit special requirements, properties, and tests, e. g. API, to actual job needs.

.1 Steel sheet piles to be in accordance with CAN3-G40.21-M21 [including chemical and mechanical requirements] Grade [350W] of [new] structural steel and following:

SPEC NOTE: Use 2.1.1.1 for flat-web piling only.

.1.1 Continuous interlocking, flat web with minimum web thickness [ ] mm and minimum mass of [ ] kg/m¨.

SPEC NOTE: Use 2.1.1.2 for Z or trough section piling only.

.1.2 Continuous interlocking [Z] [trough] section with minimum effective section modulus of [ ] per metre of wall, minimum flange thickness of [ ] mm, and minimum web thickness of [ ] mm.

SPEC NOTE: Use 2.1.1.3 as opposed to (instead of) 2.1.1.1 and 2.1.1.2.

.1.3 Sheet Piling: as manufactured by [ ], section designation [ ], or equivalent as approved by [Engineer].

.1.4 Interlocked joint strength in direct tension must not be smaller than [ ] kN/m.

.1.5 Interlocks: to be such that a section of interlock bar of [1.00] m minimum length will pass along full length of pile without binding.

.1.6 Special corners: [shop fabricate by welding as indicated] [provide standard fabricated special corners for type of sheet piling supplied].

.1.7 Mark each piece of sheet piling legibly by stencilling or die-and-stamping with Heat Number, Manufacturer's Name, and Length and Section Number.

.1.8 Do not pre-cut lifting or slinging holes in sheet piles.

.2 Miscellaneous structural steel to be [new] structural steel for [wales] [bearing plates] [wale splices] [capping plates] [support angles] to CAN3-G40.21-M1981], Grade [300W].

.3 Tie rods, sleeve nuts, and turnbuckles:

.3.1 [New] steel tie rods to be in accordance with CAN3-G40.21-M81 Grade [ ].

.3.2 Tie rods to have upset screwed ends such that diameter of upset end provides 25 % excess root area over gross area of plain tie rod.

.3.3 Sleeve nuts [and turnbuckles] to have a capacity in excess of capacity of tie rod.

.3.4 Pre-assemble, mark, and test tie rod assemblies in shop. Align threaded connection at sleeve nut or turnbuckle to tolerances of [-1/80 of normal rod diameter with deviation of center line of 1 in 160].

.4 Hexagon nuts, bolts, and washers to be in accordance with ASTM A307-82a.

PART 3 - EXECUTION

3.1 Installation

.1 Weld in accordance with CSA W59-1982 and Section 02[ ].

.2 Welding certification of Contractor to be in accordance with CSA W47.1-1983.

.3 Do not commence pile installation until all required quality control tests have been completed and test results approved.

.4 Do pile installation work in accordance with Section 02[ ] except where otherwise specified herein.

.5 Submit full details of method and sequence of installation of piling to [Engineer] prior to start of pile installation work.

.6 When installing sheet piles in a bulkhead wall by driving, the following procedure is [suggested] [required]:

.6.1 Provide temporary guide frames or bracing to hold piles in proper alignment during setting and driving.

.6.2 Drive piles two at a time. Drive first double pile to its full depth, then, place a panel of five to eight double sheet piles in guide frames and secure last double pile in location to prevent spreading of piles in panel.

.6.3 Drive end-double pile in panel sufficiently deep into the ground to ensure that it will remain plumb, then, drive remaining double piles in panel commencing with the double pile next to the end double-pile and finishing with double pile next the double pile first driven.

.6.4. After one panel has been driven, place and drive succeeding panels in similar manner. Complete the driving of the end double-pile of the first panel after the double piles of the second panel have been driven.

.7 When installation is complete, face of wall at top of sheet piles to be within 75 mm of location indicated and deviation from vertical shall not exceed 1 in 100.

.8 Cut drain holes [and install steel pipe elbows] as indicated. Provide filter material in area of holes as indicated.

3.2 Obstructions

.1 If an obstruction is encountered during the driving, leave obstructed pile and proceed to drive remaining piles. Return later and attempt to complete the driving of the obstructed pile.

.2 Advise [Engineer] immediately it is impossible to drive the pile to its full penetration and obtain direction on further steps required to complete work.

3.3 Holes

.1 Patch holes in steel pile wall, except where permanent holes are indicated. Use a [ ] mm thick plate of material equal to that of piling to patch holes and overlap not smaller than the diameter of the hole. Weld to develop full strength of plate.

.2 Make holes required in piling by means of [flame cutting] [drilling] [Do not use flame cutting without permission of [Engineer].

3.4 Cutting

.1 In flame-cutting the upper end of piles, or, when permitted, cutting holes in piles, adopt the following procedure:

.2 When air temperature is above 0°C, no pre-heating is necessary.

.3 When air temperature is below 0°C, pre-heat until the steel on each side of line of cut has reached a temperature very warm to hand (approximately 35 °C). [Tempil stick] [Temperature indicating crayons] may be used to indicate temperature.

.4 Use a torch guiding device to ensure smooth round holes or straight edges.

.5 Make cut smooth and free from notches throughout thickness. If grinding is employed to remove a notch or crack, finished radius shall be at least 5 mm.

3.5 Tie rod Anchorage System

1. Do not place backfill behind anchored bulkhead [or remove material from in front of bulkhead] until it has been completely driven, adjusted, and secured in final position by anchorage system.

2. Support tie rods at intervals along their length as indicated. Piles used for this purpose to be in accordance with Section 02[ ].

3. Fit and adjust tie rod systems so that connections at waling and anchor end of tie rods are tight before backfilling.

3.6 Toe Pinning

.1 Drive sheet piling at pinned sections to bedrock contact.

.2 Pin sheet piling at toe as indicated.

.3 Ensure that pins are placed in proper locations. Use [pipe sleeves] for alignment.

.4 Secure pins with grout in accordance with dimensions indicated.

3.7 Toe Trenching

1. Drill and blast toe trench in rock as indicated.

2. Do not remove blasted rock.

3. Ensure that rock is broken sufficiently in the blasting to permit driving piles to bottom of blasted trench.

3.8 Backfilling

SPEC NOTE: For 3.8.1, if Section Excavating, Trenching, and Backfilling is not used, specify methods of filling, lift height, and compaction as required to suit project.

1. Backfill in accordance with Section 02[ ] and as indicated.

2. Protect piling tie rods and anchorage systems from damage or displacement during backfilling operations.

PART 1 - GENERAL

1.1 Related Work

.1 [ ] [ ]

1.2 Shop Drawings

.1 Submit shop drawings in accordance with Section [ ].

1.3 Method of Measurement

SPEC NOTE: Select method-of-measurement clause(s) applicable. Ensure that unit prices for additions and deletions properly covered in contract documents.

SPEC NOTE: Delete 1.3.2 when using 1.3.1. Delete 1.3.1 when using 1.3.2.

SPEC NOTE: It may be necessary to clarify whether test piles for loading test are included with piles "for testing purposes" in 1.3.1.

.1 Installation of piles will be measured in number of piles driven and accepted [including those for testing purposes].

.2 Installation of piles will be measured in total length of piles accepted and incorporated into work.

.3 [Pile toe reinforcement] [pile shoes] are incidental to the supply and installation of piles.

.4 Mobilization and demobilization costs for all equipment [are incidental to the supply and installation of the piles and will not be measured separately] [will be measured separately].

PART 2 - PRODUCTS

2.1 Materials

SPEC NOTE: For 2.1, require material specifications and properties suitable for type of application. Consider field conditions and environmental factors.

.1 Concrete for pile to be in accordance with Section 03[ ] and have a 28-day strength not smaller than [40] MPa.

.2 Reinforcing steel to be in accordance with Section 03[ ], sizes and details as indicated.

PART 3 - EXECUTION

3.1 Installation

.1 Install piles in accordance with Section [02351].

.2 Install reinforcement in accordance with Section 03[ ].

.3 Install concrete in accordance with Section 03[ ].

.4 Allow height in piling rig sufficiently longer than anticipated length of pile for driving and extraction.

.5 Place driving tube, adjusted for true alignment at piling location.

SPEC NOTE: The volume of the concrete plug placed in the tube is usually about 0.2 m^3, but the volume necessary varies with size and soil conditions.

.6 Place a suitable amount of concrete into the tube and tamp until a compacted driving plug is formed.

.7 Drive tube with hammer dropping on plug causing tube to be pulled into the ground with plug.

SPEC NOTE: The height of the plug in the driving tube must be maintained above a minimum value.

.8 Place a marker on driving hammer cable to establish the depth to plug in tube and to aid in ensuring that a minimum height of plug is maintained at all times.

.9 After driving tube to required depth, secure driving tube to driving rig, raise driving tube and expel plug, while taking care not to drive the ram beyond the bottom of the driving tube.

SPEC NOTE: The hammer driving energy varies with the size of the driving tube, soil conditions, and intended pile capacity.

.10 Deposit small volumes of zero slump concrete at bottom of driving tube and ram concrete into soil with the hammer raising it about [ ] metre and delivering blows of [ ] Joule of energy.

.11 Successively repeat ramming and expelling of concrete into underlying soil until expanded base is formed as indicated.

.12 Install reinforcement cage in accordance with details indicated. Provide suitable and approved method of holding reinforcement cage in position.

SPEC NOTE: The optimum hammer size, travel, and driving energy when forming the shaft varies with the size of the driving tube and the soils conditions.

.13 Form shaft of pile by ramming successive quantities of concrete while progressively raising tube. Apply at least two blows of [ ] Joule energy at every [0.3] metre of shaft.

.14 Make sure that the driving tube remains below level of concrete at all times while ramming concrete and raising tube.

.15 Repeat until bottom of driving tube reaches pile cut-off elevation.

SPEC NOTE: The integrity of the completed shaft can be investigated by means of dynamic low-strain methods. Such measurements are best performed before the pile cap is poured.

.16 Do not prepare and pour pile cap until approval has been given by [Engineer].