Usage Guide for

NTPEP Audit Programs

NTPEP Designation: [NAP-1-14]

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Scope

This document serves as a usage guide for the National Transportation Product Evaluation Program (NTPEP) manufacturer audit programs or NAP (National Audit Program). NTPEP serves the member departments of the American Association of State Highway and Transportation Officials (AASHTO). This usage guide is intended to help Member Agency (DOT) engineers and technicians understand the reasoning behind why certain materials are audited at the source of production, explain how the material is evaluated, and provide various ways of using the results for material acceptance.

Background

The program was developed out of the need for standardization. Industry requested a unified approach to material acceptance while the state DOT's were experiencing a decrease in knowledge due to a reduction in workforce. This program is an attempt to help both sides

From its inception, NTPEP primarily coordinated the testing of highway materials and then published the results of that testing for the member State Transportation Agencies to use. As the NTPEP testing program grew, the need for an alternate way to evaluate certain materials (directly at the source of production) led to the development of an audit program. In 2008 the first audit was performed thereby launching the "NAP way" of handling materials. In these audit programs not only are the products sampled and tested by NTPEP designated laboratories to evaluate the products, but an on-site inspection audit is performed to review the manufacturing process, the facilities, and the manufacturer's quality control procedures.

Purpose of conducting audits

Audited products are generally produced/fabricated to an AASHTO or ASTM specification. There are a couple of reasons why some material processes are more suitable for performing audits on than others. For instance, it may be that the material has a low failure rate and is typically accepted based on a Manufacturer's Certification with possibly some limited additional testing. The audit allows the DOT to have more than just the Manufacturer's Certification and provides additional process and testing information. In other cases the equipment and expertise needed to conduct particular tests may be cost prohibitive for DOTs to own and use. In that case, the DOT typically accepts the product based on the manufacturer's own test results. The audit process provides those test results through an independent means.

In other instances the DOT may require an on-site inspection of certain types of material production facilities sometimes necessitating costly travel arrangements.

With NAP, a qualified auditor performs the on-site inspection and associated product testing. All audit findings and test results are published for DOTs to review and consider for their use. Each manufacturer requesting an audit pays a fee to participate in the program. This fee covers the costs associated with: travel, testing, and the administration of the program. Agencies utilizing the program do not incur the costs associated with the audit unless they have additional requirements than those covered under NAP.

Materials included in the audit program

Materials that are currently audited through NAP include:

- High Density Polyethylene (HDPE) and Polypropylene Pipe
- Reinforcing Steel Bar (REBAR) and Welded Wire Reinforcement (WWR)
- Polyvinyl Chloride (PVC) Profile Wall Drainage Pipe

Each of these materials has specific attributes that make it a viable area for NTPEP involvement. More detailed information about these materials is included in the appendices of this document.

Overview of the audit process

NTPEP's general process for auditing consists of:

- Conducting a pre-audit review of the Manufacturer's Quality Systems Manual;
- Conducting an on-site audit of documentation control, production, quality control testing, and storage;
- Obtaining companion samples for NTPEP Designated Laboratory testing;
- Publishing the results of the completed audit.

The audit process is described in detail in NTPEP Standard Practice SP01, "*Standard Practice for Qualification of Highway Product Manufacturers Through the Use of NTPEP Audits*" and is available on the NTPEP website at www.ntpep.org. Additionally, under each product Committee, a Work Plan has been developed that works with SP01 to address the particulars for each audited material.

Manufacturers submit an application to NTPEP for an audit and audits are scheduled on a regional basis. Auditors may handle several materials during their audit run.

State DOT materials representatives are contacted in advance of upcoming audits in their state so that they can accompany the NTPEP auditor during the site visit if they wish to do so. State DOT materials personnel are encouraged to join the auditor whenever possible so that they can be assured that all areas of concern to them are fully covered.

During the on-site inspection, the auditor typically witnesses testing of selected products and also obtains companion samples of those products for independent testing and comparison. The results are used as part of the overall audit process. Once the process has been completed, manufacturers who meet the requirements of SP01 and the particular Work Plan are listed as being "compliant". Each Work Plan has specific requirements about how long each audit is valid and how often the facility needs to be re-inspected.

Using the results of the audit process

The results of these audits are uploaded to DataMine and are available for DOTs to use as they deem best for their agency. Typically the results are used in conjunction with having a manufacturer be considered for a Qualified Product Listing. The NAP process is a standardized way to present the data. **Final acceptance (approval, certifying, etc.) is performed by the DOT**. Member Agencies may wish to use the results to:

- Place a manufacturer and directly related products from that manufacturer on a Qualified Products Listing with no additional testing. This would be a good alternative for DOTs that are currently accepting products based on manufacturer's certifications alone.
- Consider a manufacturer for a Qualified Products Listing with some additional source testing. Some DOTs may want to request or perform additional testing on a particular product and/or still take field samples for product acceptance.
- Take the DOT product inspection process to a higher level by adding the NTPEP audit as a portion of their own evaluation of the manufacturer.

Appendix A: Thermoplastic Pipe Audit Program

The HDPE Plastic Pipe and Polypropylene Technical Committees facilitate the laboratory evaluation and auditing program for Thermoplastic Pipe products in accordance with the AASHTO Materials Specifications M294, M252, and M330 respectively. These technical committees coordinate a listing of participating pipe manufacturing facilities along with specific pipe sizes, properties and auditing results. High Density Polyethylene (HDPE) and Polypropylene pipe are used for surface and subsurface drainage applications. Soil arching effect supplies the support for the flexible walls upon burying of the pipe.

A.1. Pipe Making Process

Thermoplastic pipe is manufactured as described below:

A.1.1 HDPE Pipe Manufacturing Process

HDPE is a thermoplastic material. Raw material, referred to as PE resin is supplied to the pipe producer in a non-pigmented pelletized form. The resin is combined with colorant, stabilizers, anti-oxidants and other ingredients for UV protection and enhanced properties.

Thermoplastic material can be melted with the application of heat. As the material cools long polymer chains are formed that bond together. The addition of heat allows the bonds to break and the material to take a re-moldable form. It is important to note that with each application of heat to a thermoplastic resin, known as a “heat history”, some of the polymers break resulting in increasingly shorter polymer chains. Shorter chains negatively impact the properties that are desired including tensile strength, elongation and, to a lesser degree, compressive strength. The results are a weaker, more brittle product, which is why the specifications require virgin resins with no recycled material content and limit the amount of regrind (reground post-production thermoplastic resulting from start-up operations and the production of pipe).

The typical steps of HDPE pipe and fitting production are to heat, melt, mix and convey the raw material to extruders where the pipe is shaped over a mandrel to particular diameters and allowed to cool. This process allows for the production of profile wall HDPE pipe (AASHTO M252 and M294) as well as fittings (*the NTPEP program does not address solid wall ASTM F714 material*). All pipe sizes are continuously extruded through dies by simultaneously applying heat and pressure. Larger companies may move dies from production plant to production plant as demand for various sizes changes in different regions of country.

Most HDPE Pipe manufacturers perform all of the required AASHTO and ASTM tests in-house in their plant laboratories. Others utilize a central laboratory or a third-party laboratory. In each case, the laboratory is audited as part of the NTPEP audit. Laboratories are required to maintain the records and produce them during the audit.

A.1.2 Polypropylene Pipe Manufacturing Process

Polypropylene is also a thermoplastic material. Raw material, referred to as PE resin is supplied to the pipe producer in a non-pigmented pelletized form. The resin is combined with colorant,

A.2. Audit Program

The programs were developed due to the fact that there are a number of specialized tests requiring specialized equipment and technicians who have experience performing the tests. Most AASHTO member states do not have the equipment or the trained technical staff to perform the testing. Due to the specialized testing and the unfamiliarity of member states with the testing, the NTPEP audit testing phase was introduced to instill states' confidence in the manufacturer's internal testing procedures and quality control program and in the consistency of the quality of the product being produced.

A.3. Testing

The split sample testing during the audit, is meant more to determine the quality of the testing that is being done by the manufacturers than to determine the quality of the product. Due to the amount of product typically produced by any given manufacturer, the testing of one sample is not particularly representative of the product.

ASTM D3350 recognizes six properties that are important to the manufacturing of HDPE Pipe. These properties are identified in by the cell classification and are as follows:

Density	ASTM D1505
Melt Index	ASTM D1238
Flexural Modulus	ASTM D790
Tensile Strength	ASTM D638
Slow Crack Growth Resistance	ASTM D1693
Hydrostatic Strength Classification	ASTM D2837
In addition AASHTO requires the Notched Constant Ligament-Stress test	ASTM F2136

The Plastic Pipe Institute states that molecular weight is the main factor that determines the durability related properties of the HDPE Pipe. The properties that improve with molecular weight are long term strength, toughness, ductility, and fatigue resistance.

One item that is of special interest is the blending of off specification resins into resins which meet the AASHTO requirement. Several companies are either purchasing the blended resins or are blending them in the plant. The testing process followed the companies presently involved in the blending of the resins have been reviewed by the Polyethylene Pipe Technical Committee and have been approved to supply the material.

A.4. Retests and Re-Audits

Inevitably there will be times when a resin sample or pipe sample fails to meet the requirements of the specifications or proper accepted procedures are not followed during production or testing of material.

If this occurs the manufacturer can request a retest or re-audit. The cost for any retesting or auditing will be borne by the manufacturer. The manufacturer must identify the cause and document changes to correct short falls.

Appendix B: Reinforcing Steel Audit Program Specifics

The Reinforcing Steel Technical Committee facilitates the auditing program for Reinforcing Steel products (rebar and welded wire reinforcement – WWR). The technical committee coordinates a listing of participating producing mills/manufacturing facilities along with audit results.

Reinforcing steel is used primarily for the reinforcement of concrete products (precast concrete items, concrete pavements, cast-in-place structural concrete, etc.). It generally is furnished as one of the following finished products: bars or welded wire sheets/rolls. All of these products start out in the same way.

B.1. Steel-Making Process

Reinforcing steel starts out as scrap metal (cars, appliances, machining waste, etc.) which is shredded and separated into piles based upon chemistry. Pre-determined weights are combined and melted in a large ceramic-lined steel bucket by means of an electric arc furnace. Huge positively charged electrodes are lowered into the negatively charged bucket of scrap and create an arc. This electric arc melts the scrap steel consuming everything attached (paint, insulation, etc.). All non-ferrous products, consumed during the melt, float to the surface and are poured off as slag.

The molten steel, after initial melt, is transferred to a ladle (another lined steel bucket) where certain alloying agents are added to refine the steel mixture. During this stage the chemistry is periodically tested for compliance with the particular steel recipe (specification and grade) being produced.

After mixing to the proper recipe, the molten steel is cast into rectangular “billets”. The molten steel mixture is poured into water-cooled copper molds which cast continuous rectangular sections which are cut to length, identified, and stored. The billets are identified by “heat” (cast from the same melt or ladle of steel) and are marked with the heat number and billet number. At this stage, the billet has identification and only the chemistry test results. Any physical test results will come later when the steel is a finished product.

B.2. Bar Production (Plain and Deformed)

In the production of reinforcing bars, the billets are heated to approximately 1950 ºF in a furnace and sent through a series of rollers which gradually reduce the billet into the round bar. This “hot-rolling” process can produce:

- straight or coiled deformed bar with the last set of rollers producing upset ribs/deformations
- plain bar (often called smooth round) or rod (small diameter coiled plain bar) by removing the last set of rollers (with deformations).

When tested by the producing mill's Quality Control Laboratory, physical properties (tensile, yield, elongation, bend, etc.) are determined for the heat of finished bars. Rod only has chemical properties until it is drawn (where the physical properties can me determined).

B.3. Welded Wire Reinforcement (Plain and Deformed) Production

Wire (produced from rod) can be used alone or welded to produce welded wire reinforcement. The rod is descaled (cleaned) and "drawn" or "rolled" through a series of dies to produce the required wire size (diameter). Cold-drawing/rolling reduces the diameter and provides cold-working of the steel to produce the necessary physical properties. Deformation can be produced in the wire by crimping the wire to produce indentions or by sending the wire through dies (similar to deformed bars) that produce deformations.

Welded wire reinforcement is produced by welding wire (as produced above) in the desired configurations to produce flat sheets or rolls. Welding is performed by electric resistance units capable of joining all wire intersections in a row simultaneously. Additional quality control testing is necessary to determine weld quality.

B.4. Audit Program

The audits are a review of typical daily production of highway products. Reviews of manufacturing and testing are representative of normal production. The on-site testing of samples should be what you would find any time a visit is made.

When the audit is completed, the report is forwarded to the AASHTO Supervisor for review. Once the report has been reviewed and any revisions finalized, the audit results, preaudit documentation and current Quality Manual are uploaded onto the NTPEP Audit Program (NAP) website.

B.5. Testing

It is important to know what test results are available from testing in accordance with the product specifications and how to use them. There are few chemical requirements for reinforcing steel and mainly minimum requirements for the physical tests.

Direct comparison between the product results and the documented test results shown on the Mill Test Report (MTR) will not match. For example, the chemistry of a sample taken from the steel product versus the values listed on the MTR will not match. This is due to the fact that the chemistry reported on the MTR is not a direct product test. The results are representative of the product, but may from several tests performed during the melting and mixing of the heat of steel.

The split sample testing performed, during the audit, is meant to determine the quality of the testing being done by the manufacturer. Due to the amount of product typically produced by any given manufacturer the testing of one sample is not particularly representative of the product. The AASHTO Designated Laboratory testing was introduced to instill states'

confidence in the manufacturer's internal testing procedures and quality control program and in the consistency of the quality of the product being produced.

The following acceptable limits of variation between the manufacturer's lab and the AASHTO Designated Laboratory testing are used by the NTPEP Committee in comparison of the split sample results. These limits are used to trigger further investigation into the testing practices of the plant laboratory or the NTPEP Designated Laboratory:

Reinforcing Bar

Laboratory Comparison Requirements - Test results for sample of three (3) specimens cut from the same heat and tested at each laboratory shall vary between laboratories by no more than the following:

Unit Weight…… 1.0 percent

Yield…… 10.0 percent (see Paragraph 6.2.3)

Tensile…… 10.0 percent

Elongation..... 4.0 percent

The differences in average test results for the same sample from the same heat tested at each laboratory shall vary between laboratories by no more than the following:

Unit Weight…… 1.0 percent

Yield…… 4.0 percent (see Paragraph 6.2.3)

Tensile…… 4.0 percent

Elongation..... 3.0 percent

Wire and Welded Wire Reinforcement

Laboratory Comparison Requirements - The test results for comparable sample specimens run at each laboratory shall vary between laboratories no more than the following:

Tensile.....10 percent

Unit Weight (deformed wire only) ..... 5 percent

The average test results for the same sample run at each laboratory shall vary between laboratories no more than the following:

Tensile..... 5 percent

Unit Weight (deformed wire only).....2 percent

Appendix C: Polyvinyl Chloride (PVC) Profile Wall drainage pipe Audit Program Specifics

The PVC Plastic Pipe Technical Committee facilitates the laboratory evaluation and auditing program for Polyethylene Thermoplastic Pipe products in accordance with the AASHTO Materials Specification M 304. The technical committee coordinates a listing of participating pipe manufacturing facilities along with specific pipe sizes, properties and auditing results. Polyvinyl Chloride (PVC) pipe is used for surface and subsurface drainage applications. Soil arching effect supplies the support for the flexible walls upon burying of the pipe.

A.1. Polyvinyl Chloride (PVC) Pipe Making Process

Polyvinyl chloride (PVC) is the third-most widely produced polymer after HDPE and polypropylene. Polyvinyl chloride is produced by polymerization of the monomer vinyl chloride.

Raw material, referred to as PVC powder is supplied to the pipe producer in a non-pigmented powdered form. The PVC powder requires conversion into a compound by the incorporation of additives such as heat stabilizers, UV stabilizers, lubricants, plasticizers, processing aids, impact modifiers, thermal modifiers, fillers, flame retardants, biocides, blowing agents and smoke suppressors, and, pigments. PVC has high hardness and mechanical properties. The mechanical properties enhance with the molecular weight increasing, but decrease with the temperature increasing.

The typical steps of PVC pipe and fitting production are to heat, melt, mix and convey the raw material to extruders where the pipe is shaped over a mandrel to particular diameters and allowed to cool. This process allows for the production of solid and profile wall pipe as well as fittings. All pipe sizes are continuously extruded through dies by simultaneously applying heat and pressure. Most of the PVC Pipe manufacturers perform all of the required AASHTO and ASTM tests in the plant laboratories. They are required to maintain the records and produce them when audited.

A.2. Audit Program

The program was developed due to the fact that there are a number of specialized tests requiring specialized equipment and technicians who have experience performing the tests. Most AASHTO member states do not have the equipment or the trained technical staff to perform the testing. Due to the specialized testing and the unfamiliarity of member states with the testing, the third party testing phase was introduced to instill states' confidence in the manufacturer's internal testing procedures and quality control program and in the consistency of the quality of the product being produced.

The split sample testing is meant more to determine the quality of the testing that is being done by the manufacturers than to determine the quality of the product. Due to the amount of product typically produced by any given manufacturer, the testing of one sample is not particularly representative of the product.

A.3. Testing

ASTM D3350 recognizes six properties that are important to the manufacturing of PE Pipe. These properties are identified in by the cell classification and are as follows:

Density	ASTM D1505
Melt Index	ASTM D1238
Flexural Modulus	ASTM D790
Tensile Strength	ASTM D638
Slow Crack Growth Resistance	ASTM D1693
Hydrostatic Strength Classification	ASTM D2837
In addition AASHTO requires the Notched Constant Ligament-Stress test.	ASTM F2136

The Plastic Pipe Institute states that molecular weight is the main factor that determines the durability related properties of the PE Pipe. The properties that improve with molecular weight are long term strength, toughness, ductility, and fatigue resistance.

One item that is of special interest is the blending of off specification resins into resins which meet the AASHTO requirement. Several companies are either purchasing the blended resins or are blending them in the plant. The testing process followed the companies presently involved in the blending of the resins have been reviewed by the Polyethylene Pipe Technical Committee and have been approved to supply the material.

A.4. Retests and Re-Audits

Inevitably there will be times when a resin sample or pipe sample fails to meet the requirements of the specifications or proper accepted procedures are not followed during production or testing of material.

If this occurs the manufacturer can request a retest or re-audit. The cost for any retesting or auditing will be borne by the manufacturer. The manufacturer must identify the cause and document changes to correct short falls.