PROCEDURES FOR EVALUATING APPLICANT PIT TAGS

Description of tests that shall be conducted to determine if the applicant tags can be successfully adapted to the PIT-Tag systems installed throughout the Columbia River Basin

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INTRODUCTION

During the transition from the old 400-kHz PIT-tag technology to the current ISO-based 134.2-kHz system in the late 1990s, a rigorous series of tests were developed to ensure a smooth transition. These tests were designed to compare the two technologies and verify that the new ISO-based systems would perform as well or better than the then current system (400-kHz) for applications in the Columbia River Basin (CRB). Tests to determine tag-reading performance were largely based on an automated belt driven test fixture and shielded antennas that would allow a large number of tag reads to be quickly run in a controlled environment. This *testing methodology has since proven to be a good indicator of how a particular tag or reader will perform in the CRB and is considered to be a standard method for comparison*. For example in 2003, Brad Peterson used the methodology to compare the performance of two models of PIT tags manufactured by Digital Angel Corporation (formerly Destron Fearing) for PTOC (PIT Tag Operations Center). Based on those tests and some fish tests, the PIT Tag Steering Committee (PTSC) approved the use of tag model TX-1400ST for widespread use in the CRB.

A primary concern in adopting emerging tag technologies (improved-read-range tags or tags with alternative encapsulation material) is how well the interrogation systems already installed in the juvenile fish facilities at the hydroelectric dams will detect them. These interrogation systems have the potential for multiple tags of different technologies to pass through the same antennas within short periods of time. In addition, these antennas are small (some are wrapped around 6" PVC pipes) and all are close together (typically in one monitor, there are four coils wrapped within a 96" span) and therefore they have more potential to be impacted by longer read range tags than the interrogation systems for adult salmonids with their larger antennas spaced at least 10 feet apart. There have been discussions that in order to maximize the detection of improved-read-range tags, the antennas may need to be changed (e.g., clamped down to reduce the effective size of their electromagnetic fields). Belt tests offer an effective tool for determining how well a mix of current and improved-read-range tags will be read in the current antenna system and for identifying potential changes in antenna configurations to optimize reading performance for a mix of tags. Therefore, belt tests conducted to determine whether an improved-read-range tag is acceptable for widespread use in the CRB may well need to test the tags using multiple antenna configurations (i.e., the current antenna configuration, a compromise configuration, and an antenna configuration which maximizes the tag-type being tested).

For the adult ladder interrogation systems there is less concern about a mixture of existing and improved-read-range tags impacting these systems because tagged fish densities are significantly lower and the antennas are farther apart. The main concern is that improved-read-range tags are detectable in the larger antennas located in the adult ladder systems. Therefore, *we still* need to confirm that the improved-read-range tags can be detected in these antennas because unlike the interrogation systems installed in the juvenile fish facilities, the antenna configurations for these interrogation systems cannot be adjusted.

Stipulation: *Before any tests are conducted*, the tag manufacturer will need to petition PTSC to have their tags tested (see next page). PTSC shall designate whether the applicant tags being tested have the potential for widespread use in the future. If there is no potential for widespread use, the tags shall only be tested with the current antenna configuration (i.e., the antennas would not be modified).

PIT Tag Steering Committee

Check-off list for Evaluation of Applicant PIT tags

Tag information

Vendor/Manufacturer ___________________________________

Model information ___________________________________

Tag details (dimensions/weight) ___________________________________

Encapsulation material ___________________________________

Date request submitted to PTSC ___________________________________

Number of tags submitted ___________________________________

Anticipated Usage Pattern

☐ Non-critical tag – Limited use within the Columbia River Basin

☐ Critical tag - Widespread use within the Columbia River Basin

Year when tag would become primary tag __________

Would PTSC be willing to accept modified antenna configurations in the juvenile systems that would allow the applicant tag to be read at $\geq$ 95%, but the current tag at <95%?

Yes_____ No_____

PTSC Requests the following tests be performed on the submitted tag model

☐ Section A. Basic preliminary tests to determine if the applicant tag performs satisfactory with current antenna configurations

☐ Section B. Determine how the antenna configurations for the juvenile fish facilities could be modified to yield satisfactory performance ($\geq$ 95% reading efficiency)

☐ Section C. Measure tag parameters to determine variability (e.g., length, weight, resonant frequency)

☐ Section D. Read ranges under different noise levels

☐ Section E. Maximum read speed under different noise levels

☐ Section F. Two-same-tag grouping/proximity tests

☐ Section G. Two-different tag grouping/proximity tests

☐ Section H. Three-same-tag grouping/proximity tests

☐ Section I. Three-different-tag grouping/proximity tests

☐ Section J. Portable or handheld transceiver tests

☐ Section K. Large antenna tests

GENERAL SET-UP ISSUES

I. Basic Test Criteria

A minimum of 500 “Applicant” tags shall be provided to the group testing the tags. Another 500 tags of the standard tag (currently this is model TX-1400ST by Digital Angel) shall be randomly chosen for testing. For future tests, whatever is the current tag model being mostly used in the CRB, as decided by the PTSC, shall be used as the standard tag in those tests. Of the 500 tags provided by the manufacturer, a subset will be randomly selected for the following tests:

A. *To evaluate the impact of the applicant tag on the interrogation systems for juvenile fish*, two different sized round antennas (6” and 12” diameter) shall be tested. For each sized antenna, whenever possible dual coils that are configured the same as they are at the juvenile fish facilities shall be evaluated. Each coil shall be hooked up to a Destron-Technologies FS1001 transceiver, which is the transceiver currently being used at most of the juvenile fish facilities. Tests shall be performed in a RF-shielded room with a belt platform using both shielded and unshielded antennas. The belt platform available to PTOC for this testing has a maximum belt speed of 27 ft/sec and the belt is 24 ft long. Belt speeds shall be within 0.25 ft/sec of the stated values.

B. *To evaluate the impact of the applicant tag* on *the interrogation systems for adult fish*, one sized antenna shall be tested (a 26” by 26” orifice antenna). For this evaluation, a single coil shall be tested. The antenna shall be connected to a Destron-Technologies FS1001A transceiver, which is the transceiver currently being used for the adult systems. Tests shall be performed in a RF-shielded room with a belt platform with the orifice antenna sometimes shielded and sometimes unshielded.

II. Test Metrics and Parameters

A. Transceivers shall be connected to a computer via the RS-232 port, so that the data collected shall be permanently recorded and archived.

B. Transceiver settings shall be recorded. Examples of transceiver settings include the exciter current amperage, exciter voltage, exciter phase, voltage on the comparator, and signal noise range. Transceiver IDs shall be recorded.

C. For the transceivers, noise shall be measured on the analog board using the FDX-B test point instead of relying on the displayed values. The FDX-B test point produces a 5V or 5000 mV (peak to peak) signal when it is at its maximum (i.e., when a tag is being read). When there are no tags in the field, the minimum baseline voltages recorded at the test point by the FS1001 transceivers are typically around 480-500 mV while they are around 120-160mV for the FS1001A transceivers. All of the noise measurements made in the following tests shall be above the baseline voltages recorded by the individual transceivers.

D. Antenna configuration parameters and tuning procedures results shall be recorded. Examples of antenna configuration parameters include the coil width, the distances from the coil to each of the proximal shield walls, and the proximal distance between coils. A calibrated (certified) Quadtech or equivalent LCR meter shall be used to measure the inductance and Q values. A description of the shield shall also be recorded. Antenna IDs shall be recorded.

E. A description of how the tags are attached to the belt shall be given. Tags shall be mounted so all face the same direction (e.g., all shall have the tag’s antenna end facing the direction that first enters the antenna).

F. Before belt tests can be conducted, the evaluators shall determine the minimum non-interfering distance between the tags of the same model using both shielded and unshielded antennas. They shall then increase the longer of the two distances between tags by 15% and use that distance for separating tags in the below tests. This will often determine how many sets of tags can be used in the different tests.

EVALUATION

A. Preliminary tests with current antenna configurations

The first step is to determine how well the applicant tags read with existing antenna configurations in a RF-shielded room (see above stipulation that this is the only configuration that will be tested for the non-critical tags, which PTSC deems will not have widespread usage in the Columbia River Basin).

- *Juvenile system* – The existing antenna configuration for the 6" antenna that shall be tested are two 8" wide coils that contain 57 wraps of 10-gauge wire spaced at 0.144" apart with 18-20" space between the coils; each coil is 6" from the shield's edge. The existing antenna configuration for the 12" antenna that shall be tested are two 8" wide coils that contain 32 wraps of 10-gauge wire spaced at 0.325" apart with 20" space between the coils; each coil is 6" from the shield's edge. The tuning inductance for both of these is 370±10 µH.
- *Adult system* – The existing antenna configuration that shall be tested is a 26" by 26" antenna that has a fiberglass housing surrounding the coil. The antenna coil is 2" from the inside edge (drawings are available upon request). The coil is wrapped with 13-15 wraps of 16 gauge wire over 6". The circuit contains five 4700-pf capacitors (3 in parallel connected in series with the second group of 2 capacitors connected in parallel) to yield a capacitance of 5640 pf and the tuning inductance is 325±5 µH. An aluminum shield surrounds the perimeter of the housing and is located 8" from the coil.

For this set of preliminary tests with the current antenna configurations, a minimum of 10 applicant tags shall be tested. Because the belt available is only 24 feet long, it is unknown how many tags can be attached when separating them by the non-interfering distance determined above. Therefore, it may be necessary to run the individual tests multiple times to get the minimum of 2000 tags passing through the antennas.

The tags in the 0° orientation shall be attached to the belt at the appropriate non-interfering distance apart for each antenna size. Noise levels as recorded at the FDX-B test point on the transceivers shall be kept at a minimum (<250 mV above the baseline voltage; below 100 mV if possible) and the levels during testing shall be recorded. The belt shall be placed in the center of all of the shielded test antennas and also 1" from the edge for the 12" antenna and the adult antenna. The belt shall be operated at 13 ft/sec (±0.25 ft/sec) or 4 m/sec. For each test, the belt shall be rotated so that a minimum of 2000 tags pass through a test antenna (for the juvenile systems, each coil of the dual-coil configuration shall be consider independent) using a minimum of 10 different tags (this may mean that multiple replicates will need to be run to generate data on 10 or more tags). Then the reading efficiency rate for each test antenna configuration shall be calculated (# tags detected / # tags passed).

Testing of applicant tags deemed to have widespread usage in the Columbia River Basin will skip to Section C if they pass these preliminary tests. Testing of applicant tags deemed to have widespread usage in the Columbia River Basin will proceed to Section B if the applicant tags are not detected at 95% or better efficiency rates with either of the antennas for the juvenile system.

Testing of applicant tags deemed to have widespread usage in the Columbia River Basin will stop if the applicant tags are not detected at 90% or better efficiency rates with the adult antenna with the belt in the center or near the edge (because the configurations for these antennas cannot be modified).

Testing of tags deemed NOT to have widespread usage in the Columbia River Basin will stop if:

- The applicant tags are not detected at 95% or better efficiency rates with the antennas for the juvenile systems. Users can use them at their own risk if the standard tag can still be read at 100% in the juvenile system when the two tag types are separated by 12" (see Section G).
- The applicant tags are not detected at 90% or better efficiency rates with the adult antenna with the belt in the center or near the edge.

B. Modified antenna configurations

If the applicant tags are deemed by PTSC to have widespread usage in the Columbia River Basin, then the evaluators shall, if possible, determine how to modify the current antenna configurations for the juvenile system so that both the standard and applicant tags can be detected at 95% (90% would be acceptable for the tag likely to be little used during the outmigration season when both would be in the migrating tagged fish). If the antennas are modified in any way, then the above set of preliminary tests shall be repeated with both tag types (standard and applicant) to determine reading efficiencies for both. Before the preliminary tests shall be repeated with the modified antennas, the evaluators shall determine the non-interfering distances for the modified antenna configurations.

Examples of how the 6" and 12" sized antennas might be modified include clamping down both antenna coils to reduce their effective electromagnetic fields; altering one coil and leaving the other coil in its original configuration. If a compromised modified antenna configuration cannot be determined, then it may be possible to change one set of two coils for optimally detecting the applicant tag while leaving the other set of two coils in the current antenna configuration (in a four-coil monitor, there are typically two shields, each containing two coils). This arrangement would have to be tested outside of the RF-shielded room because of the belt inside is not long enough to accommodate a four-coil monitor.

Depending on the results of these tests, the rest of the evaluation may be conducted with the standard antenna configuration, a compromise antenna configuration, or separate optimal antenna configurations for each tag type.

If the antennas are successfully modified, details of the modified antenna configurations shall be recorded.

Even if the applicant tags are deemed by PTSC to have potential for widespread usage in the Columbia River Basin, the testing will stop at this point and the applicant tags would not be recommended for widespread use in the Columbia River Basin if:

- The applicant tags are not detected at 95% or better efficiency rate with any antenna configuration for the juvenile systems with the belt in the center of the antennas.
- The antenna configuration cannot be modified to make the applicant tags detectible at the 95% level with the belt near the edge of the antenna.
- The antennas in the juvenile system cannot be modified so that at least 90% of standard tag model are still detected while maintaining a 95% level for the applicant tag model unless PTSC has indicated that they would be willing to accept an interrogation system where only the applicant tag can be effectively interrogated ($\geq$ 95%).

If the test results at this point indicate that the applicant tag is unacceptable for widespread usage, then users can use them at their own risk if the standard tag can still be read at 100% in the juvenile system when the two tag types are separated by 12" (see Section G).

C. Check on applicant tag variability

1) Determine the number of nonfunctioning tags by trying to read 400 tags with a portable transceiver set to 30% operating power while plugged into AC. We recognize that the batch of 500 tags delivered by the manufacturer might not be as random as we would like, but we will use the following for obtaining the sample for the current tags. We will use 4 vials that were randomly chosen from the PSMFC stock. The current tags we receive from Digital Angel have gone through a number of steps in the quality control process where the tags are mixed several times in large batches before they are finally placed into vials for final shipping to PSMFC (please send a request if you want details of this process). Therefore, each vial already contains tags produced over a 1-4 week time period.

2) Measure the individual length and diameters (in millimeters) of 30 tags to the second decimal point. The tags will be individually measured using a micrometer that measures accurately to ∀0.01 mm (e.g., Starrett Model 721). Record the individual values and determine the average value and the standard deviation.

3) Measure the individual weight (in grams) of 30 tags to the second decimal point. The tags will be individually weighed on an electronic analytical balance that weighs accurately to ∀0.0001 g (e.g., Mettler AE100). Record the individual values and determine the average value and the standard deviation.

Use the same 30 tags for tests described in 4 and 5.

4) Determine the 100% read range of 30 tags attached to belt in the 0° orientation (attach the tags so that the antenna end of tag enters the test antenna first) in the center of an <u>unshielded</u> 12" pipe with an antenna wrapped around it (what antenna(s) is/are used depends on Sections A and B) with the FS1001 registering minimum noise levels (<250 mV above the baseline voltage; below 100 mV if possible) within the shielded room. The read percentage of 100% is based on the number times a tag is read divided by 100 tag message transmissions. This capability is built into the transceiver. Read range measurements shall be made to the 0.25-inch level. Connect the record of the individual values with its unique tag code and then determine the average value and the standard deviation (determine median value if the data are not distributed normally).

5) Measure the electrical parameters, turn-on voltage, resonant frequency, and 3-db bandwidth for the 30 tags. Connect the record of the individual values with its unique tag code and then determine the median values for these since the values tend to have distinct values instead of being spread over a continuum.

   These tests will be performed using a test apparatus designed by PSMFC (Fig. 1) that includes a 3.5" drive coil and a 0.2" pickup coil concentrically wrapped on a custom machined nylon form, which will locate the PIT tag in the center of the driven field and pickup coil. The coil will be driven with a modified Destron-Fearing FS2001F-ISO transceiver to enable the amount of excitation to be varied in minute increments. And the drive coil will be tuned using a Destron Fearing AN4930A tuning box.

   The "turn on" voltage shall be measured for each tag using the function generator set to generate a sine wave at 134.2 kHz with a starting voltage setting of 0.30 Vpp. After the tag is inserted, if the tag does not turn on at 0.30 V, then the amplitude of the function generator shall be increased in 0.01 V increments, waiting at least two seconds between increases, until the transceiver registered multiple reads of the PIT tag. The value shall then be recorded.

The resonant frequency and bandwidth shall be measured for each tag using the function generator set to output a sweep sine wave from 94.2 kHz to 174.2 kHz (repetition rate 1 kHz with constant amplitude of 2.50 Vpp). The spectrum analyzer shall then be used to determine the peak of the signal and the 3dB bandwidth.

Figure 1. Photo showing the setup used by PSMFC to measure the electrical parameters.

Even if the applicant tags are deemed by PTSC to have potential for widespread usage in the Columbia River Basin, the testing will stop at this point and the applicant tags would not be recommended for widespread use in the Columbia River Basin if:

- The 100% average read range for the applicant tag is < 5".
- The standard deviation of any of the values is > 2.0.

D. Read ranges under different noise levels

In the RF-shielded room under three noise levels determine the 10% and 100% read ranges for tags attached to the belt at angles of 0°, 45°, and 67° off the initial orientation axis. These tests shall be conducted with the same 10 tags. The tags shall be attached to belt so that antenna end of tag enters the test antenna first. The read percentages of 10% and 100% are based on the number times a tag is read divided by 100 tag message transmissions (this capability is built into the transceivers).

These tests shall be conducted with unshielded antennas under three noise levels: mildly, moderately, and strongly interfering signals. The FDX-B test point produces a 5V signal when it is at its maximum (i.e., when a tag is being read). These tests shall be conducted when the FDX-B test point measures 150 mV (peak to peak), 500 mV, and 1250 mV above the baseline voltage (these generally relate to 3, 10 and 25% noise levels displayed by the transceiver). These ambient noise levels shall be controlled by driving an H-field antenna with a signal generator operating at 132.2 kHz (i.e., 2 kHz off of the nominal tag frequency of 134.2 kHz). The H-field antenna shall be located in the RF-shielded room.

1) *Juvenile systems* – This test shall be conducted using one FS1001 transceiver connected to one coil only (although it may need to be conducted with several different antenna configurations depending on the results of Sections A and B). Read range measurements shall be made to the 0.25-inch level. With this setup, the shortest measurement that can be recorded is 1.0 inch.

   Tests shall be conducted with the belt in the center of unshielded 6” and 12” antennas. With the belt at the side (1” from the edge) of an unshielded 12” antenna, tests shall be conducted only at the 500-mV noise level. If the applicant tags cannot be detected at the 100% level for the 0°-oriented tags with the belt in this side position, further tests shall be conducted at the 150-mV noise level.

Even if the applicant tags are deemed by PTSC to have potential for widespread usage in the Columbia River Basin, the testing will stop at this point and the applicant tags would not be recommended for widespread use in the Columbia River Basin if the following results occur:

- The average 100% read range for the 0°-oriented applicant tag with the belt in the middle of the 12” pipe is < 5” with a noise level of 150 mV.

2) *Adult system* – This test shall be conducted using one FS1001A transceiver. Similar to the series of tests for the 12” antenna, this series of tests shall be conducted with the belt in the center for determining read ranges at all three noise levels and unless problems occur, tests shall only be conducted at the 500-mV noise level with the belt 1” from the inside edge of the housing of the unshielded adult antenna. If the applicant tags cannot be detected at the 100% level for the 0°-oriented tags with the belt in this side position, further tests shall be conducted at the 150-mV noise level. Read range measurements shall be made to the 0.25-inch level. With this setup, the shortest measurement that can be recorded is 2.0 inches from the antenna because of the housing surrounding the antenna.

Even if the applicant tags are deemed by PTSC to have potential for widespread usage in the Columbia River Basin, the testing will stop at this point and the applicant tags would not be recommended for widespread use in the Columbia River Basin if the following results occur:

- The average 100% read range for the 0°-oriented applicant tag with the belt in the middle of the 26” x 26” orifice antenna is < 5” with a noise level of 150 mV.

E. Maximum read speed under different noise levels

To try to minimize the time it takes to perform these tests, conduct the tests in the highest noise level (1250 mV) first. If 95% of the tags can be detected at the maximum speed at this noise level for any of the orientations, then the tests for that orientation at the lower noise levels do not need to be run. Next conduct the tests at the middle noise level (500 mV) for the tag orientations that still need to be run. Again, if 95% of the tags can be detected at the maximum speed at this noise level for any of the orientations, then the tests for that orientation at the lowest noise level do not need to be run. Then if necessary, run any additional tests at the lowest noise level.

1) *Juvenile systems* – Depending on the results from Sections A and B on antenna configurations, this test could be conducted with multiple configurations for the two sizes of antennas (6" and 12"). Regardless of antenna configuration, two coils shall be tested simultaneously and the two coils shall be unshielded. Each coil shall be connected to a FS1001 transceiver and connected to a common computer.

   The evaluators shall determine the maximum read speed (belt speed) at which the reading efficiencies for two coils combined yield 95% or greater value for tag angles of 0°, 45°, and 67° for each tag type using the same three levels of noise (150, 500, and 1250 mV above the baseline voltage) as in Section D. Tests shall be conducted with a minimum of 10 tags, which shall be positioned on the belt the set non-interfering distance apart (this may mean that multiple replicates will need to be run to generate data on 10 or more tags). Results shall be recorded for each of the two coils separately and combined. The reading efficiencies shall be determined using a minimum of 2000 tag passes (if it were 2000, then 1900 detections would represent the minimum 95% acceptance level for the tag). Belt speeds shall be within 0.25 ft/sec of the recorded values.

   All noise levels shall be tested with the belt in the center of unshielded 6" and 12" antennas. With the belt at the side (1" from the edge) of the 12" antenna, tests shall be conducted only at the 500-mV noise level. If the applicant tags cannot be detected at the 95% level for the 0°-oriented tags at 13 ft/sec (4 m/sec) with the belt in this side position, further tests shall be conducted at the 150-mV noise level.

2) *Adult system* – This test shall be conducted using only the applicant tag type with the belt going through the unshielded adult antenna. Determine the maximum read speed (belt speed) at which the reading efficiencies for that one coil yields 90% or greater value for tag angles of 0°, 45°, and 67° using the same three levels of noise (150, 500, and 1250 mV above the baseline voltage) as in Section D. Tags shall be positioned on the belt the set non-interfering distance apart and reading efficiencies shall be determined using a minimum of 2000 tag passes. Belt speeds shall be within 0.25 ft/sec of the recorded values.

   All noise levels shall be tested with the belt in the center of the antenna. With the belt at the side (1" from the edge), tests shall be conducted only at the 500-mV noise level. If the applicant tags cannot be detected at the 95% level for the 0°-oriented tags at 13 ft/sec (4 m/sec) with the belt in this side position, further tests shall be conducted at the 150-mV noise level.

Even if the applicant tags are deemed by PTSC to have potential for widespread usage in the Columbia River Basin, the testing will stop at this point and the applicant tags would not be recommended for widespread use in the *Columbia River Basin if:*

- The applicant tags in any of the tests cannot be detected at maximum read speeds of at least 13 ft/sec (4 m/sec) for the 0°-oriented tags at all noise levels.
- The applicant tags in any of the tests cannot be detected at maximum read speeds of at least 13 ft/sec (4 m/sec) for the 0° and 45°-oriented tags at all noise levels.

F. Two-same-tag grouping/proximity tests

This series of tests shall only be done with the antennas for the *juvenile system* as grouping is not considered a significant problem with the interrogation systems for adult salmonids. Similar to Section E, depending on the results from Sections A and B on antenna configurations, this test could be conducted with multiple antenna configurations for the two sizes of antennas (6” and 12”).

The evaluators shall determine the effect on reading efficiency for each tag type at a fixed belt speed (13±0.25 ft/sec) with each set of tags separated by different distances. Except for the corner collector surface bypass facility, juvenile fish go through antennas at a maximum of 13 ft/sec in the fish facilities, which is why this belt speed was chosen. The belt (and tags) shall only be tested in the center position. Regardless of antenna configuration, two coils shall be tested simultaneously and the two coils shall have standard aluminum shields around them (standard shield dimensions are a minimum of twice the pipe size with lengths of 48” for two coils). Noise levels shall be kept at a minimum (<250 mV above the baseline voltage; below 100 mV if possible) and the levels during testing shall be recorded.

There shall be a minimum of 5 replicate tag groups. Within each tag group, set distances shall separate tags (e.g., Tag1-testspace-Tag2) and then each tag group shall be separated from the next group by the non-interfering distance. Again, reading efficiencies shall be calculated out of a minimum of 2000 detections. Results shall be recorded for each of the two coils separately and combined.

In this first test, Tag1 and Tag2 shall be the same tag type and only tags in the 0° orientation shall be tested. Determine reading efficiencies when tags are separated by 12”, separated by 6”, and separated by 3”. If the reading efficiency of the second tag equals 0, then there is no reason to conduct the shorter separations. If the reading efficiencies when tags are separated by 12” are not 100% for all tags, then run a test with the tags separated by 24”.

Even if the applicant tags are deemed by PTSC to have potential for widespread usage in the Columbia River Basin, the testing will stop at this point and the applicant tags would not be recommended for widespread use in the Columbia River Basin if:

- The applicant tags cannot be detected at 100% when two tags are separated by 12” in the 12” antenna.

G. Two-different tag grouping/proximity tests

These tests shall be identical to Section F except that in this test, Tag1 and Tag2 shall be the different tag types. There will be a difference in detection based on tag order with the weaker tag being detected less well when the stronger tag is first. Therefore, in Test G1, Tag1 shall be the standard tag type and in Test G2, Tag1 shall be the applicant tag type. Reading efficiencies for each test shall be calculated separately for the different tag types.

As in Section F, the belt shall be run at 13±0.25 ft/sec with the tags in the 0° orientation separated by different distances (12", 6", and 3"). Reading efficiencies for each tag type shall be calculated out of a minimum of 2000 detections for the 6" and 12" pipe setups. Results shall be recorded for each of the two coils separately and combined. If the reading efficiency of the second tag equals 0, then there is no reason to conduct the shorter separations. If the reading efficiencies when tags are separated by 12" are not 100% for all tags, then run a test with the tags separated by 24".

Even if the applicant tags were deemed by PTSC to have potential for widespread usage in the Columbia River Basin, having a mixture of tags would <u>not</u> be recommended for widespread use in the Columbia River Basin if:

- Both tag types cannot be detected at 100% when the two tag models are separated by 12" in the 12" antenna.

H. Three-same-tag grouping/proximity tests

In this series of tests, the tag group will consist of three tags that are all of the same type. In this scenario, the middle tag will not be detected as well because both outside tags will affect it by reducing the time it can be read without another tag being in the field simultaneously. Therefore, the two outside tags will behave similarly and the middle tag will behave uniquely. Therefore, reading efficiencies shall be calculated for these two subgroups separately (i.e., outside tags and middle tag).

These tests shall use the same shielded antenna setup as in Section F. There shall be a minimum of 3 (depends on belt length and the established non-interfering distance) replicate tag groups, each with three tags. Within each tag group, set distances shall separate tags (e.g., Tag1-testspace-Tag2-testspace-Tag3) and each tag group shall be separated from another by the non-interfering distance. Depending on how many 3-tag replicate groups can be run simultaneously, the reading efficiencies shall be calculated out of a minimum number of 2000 detections. Results shall be recorded for each of the two coils separately and combined.

The belt shall be run at 13±0.25 ft/sec with the tags in the 0° orientation separated by different distances (12", 8", and 6") through the 6" and 12" antennas. These distances shall provide estimates for the separation distance where all three tags are detected at the 100% reading efficiency level and for the separation distance where the middle tag yields a 0% reading efficiency. If the reading efficiencies when tags are separated by 12" are not 100% for all tags, then run a test with the tags separated by 24". If necessary, other tag separation distances shall be utilized to yield these estimates.

Even if the applicant tags were deemed by PTSC to have potential for widespread usage in the Columbia River Basin, the applicant tags would not be recommended for widespread use in the Columbia River Basin if:

- If the applicant tag type in the middle position cannot be detected at 100% when the tags within a single tag group are separated by 12" in the 12" antenna.

I. Three-different-tag grouping/proximity tests

These tests shall be identical to Section H except that in this test, the end tags shall be the stronger tag type and the middle tag, the weaker tag type. Reading efficiencies shall be calculated separately for the different tag types.

As in Section H, the belt shall be run at 13±0.25 ft/sec with the tags in the 0° orientation separated by different distances (12", 8", and 6") through the 6" and 12" antennas. There shall be a minimum of 3 (depends on belt length and the established non-interfering distance) replicate tag groups, each with three tags. Depending on how many 3-tag replicate groups can be run simultaneously, the reading efficiencies for each tag type shall be calculated out of a minimum of 2000 detections. Results shall be recorded for each of the two coils separately and combined. If the reading efficiencies when tags are separated by 12" are not 100% for all tags, then run a test with the tags separated by 24".

Even if the applicant tags were deemed by PTSC to have potential for widespread usage in the Columbia River Basin, having a **mixture** of tags would <u>not</u> be recommended for widespread use in the Columbia River Basin if:

- If the middle tag cannot be detected at 95% or better when all of the tags are separated by 12" in the 12" antenna.

J. Portable reader evaluation

Tests shall be conducted with two FS2001 portable transceivers manufactured by Destron Technologies with each having the following setup:

- Racket style antenna (6.8" ID)
- 2-meter cable
- Communication cable connected to a computer
- Firmware PTS2001T 5.0 – November 2004 version (or the latest firmware)

Both AC and DC power operations will be tested using the transceivers set up as follows:

- Fully charged batteries operating on DC power – set at 50% power level
- Running on AC set at 30% power

Test 1. Determine read range of both tag models

Run the below test first with the readers using DC power and then with the readers using AC power.

Using 10 tags of each model in the 0° orientation with the tags perpendicular to the face of the loop antenna, determine the maximum distance when each tag can still be read shall be measured using one portable transceiver. The evaluators shall calculate the averages and standard deviations for both tag models. The noise level without any tags in the field shall be recorded several times during the testing.

Test 2. Evaluate reader and tag interference

Run the below test first with the readers using DC power and then with the readers using AC power.

Using two portable readers that are separated by 2 feet, determine if the readers can detect both tag types in the 0° orientation at 50% of the read range determined in Test 1. Then determine if 0°-orientated tags of all combinations (applicant tags in both readers, current tag in both readers, applicant tag in one reader and current tag in other reader) can be read on both readers simultaneously regardless of distance from the loop antenna. If the tags cannot be read, determine the minimum distance that the readers need to be apart for operating.

K. Large antenna test

Use the same 800 tags of the current tag model and the applicant tag model that were used to determine the number of nonfunctioning tags in Section C. For this test, PSMFC fabricated a 4' X 4' test antenna, which was the largest size that fit without interference into their screen room. These tests with the 4' by 4' test antenna are being conducted for two reasons: 1) to investigate whether the read range of the applicant tag in proportion to the current tag changes significantly with a larger antenna and 2) to determine if a correlation existed between read range and any of the three electrical parameters measured (resonant frequency, turn-on voltage, and 3-dB bandwidth) for the applicant tag.

The test antenna was made with fiberglass (FRP) channel, it has 8 wraps of 16AWG wire, a 4559pf capacitor bank, and an inductance of 385uH (Fig. 2). The antenna shall be attached to a FS1001A transceiver. The noise level displayed by the transceiver during the testing shall be in the 3-5% level.

Figure 2. Photo showing the large antenna and how read-range distances were measured with tags placed along the Z-axis out from the center of an antenna.

All read-range distances for the evaluation shall be measured along the Z-axis out from the center of the antennas (Fig. 2). The read-range distances shall be measured when the transceiver is steadily detecting 10 tag codes out of 100 attempts in the continuous read mode. Record the read range distance to the nearest 0.25 inch. The electrical parameters shall be measured using the same procedures and the same test apparatus that were described in Section C.

In the datasheet for this test, the individual read-range distance and electrical parameter measurements shall be connected to the tag code for each tag. Medians, minimum values, and maximum values shall be determined for each parameter.

In analyzing the results, graphs shall be made that show the tag distributions for both the ST and applicant tag models based on read-range measurements and each of the three electrical parameters. As part of the correlation investigation, graph the read-range data against each of the electrical parameters.

REFERENCES

Peterson Engineering Services. 2003. Super Tag and Standard Tag Comparison Test. Report to Pacific States Marine Fisheries Commission. 53 p.