

Sequential Coded Wire Tags for Identification of Small Groups and Individual Specimens (U.S. Patent #4,955,396)

The **Binary Coded Wire Tagging** system is the most widely used method of marking fish for scientific purposes. The *Standard* Binary Coded Wire Tag is designed to identify "batches" of fish, and is impractical for identifying small groups and individual specimens. The development of *Sequential* Coded Wire Tags addresses this need.

Coded Wire Tag Format

A Coded Wire Tag (CWT) consists of stainless steel wire which is 0.25 mm in diameter cut into increments ranging from 0.5 mm to 2.0 mm long. The injector cuts the tag from a spool of wire, magnetizes and implants it into the specimen through a hollow needle. Specialized magnetic detectors are used to detect and recover the tags. To be read, the tags must be removed from the specimen and examined under magnification (Figure 1).

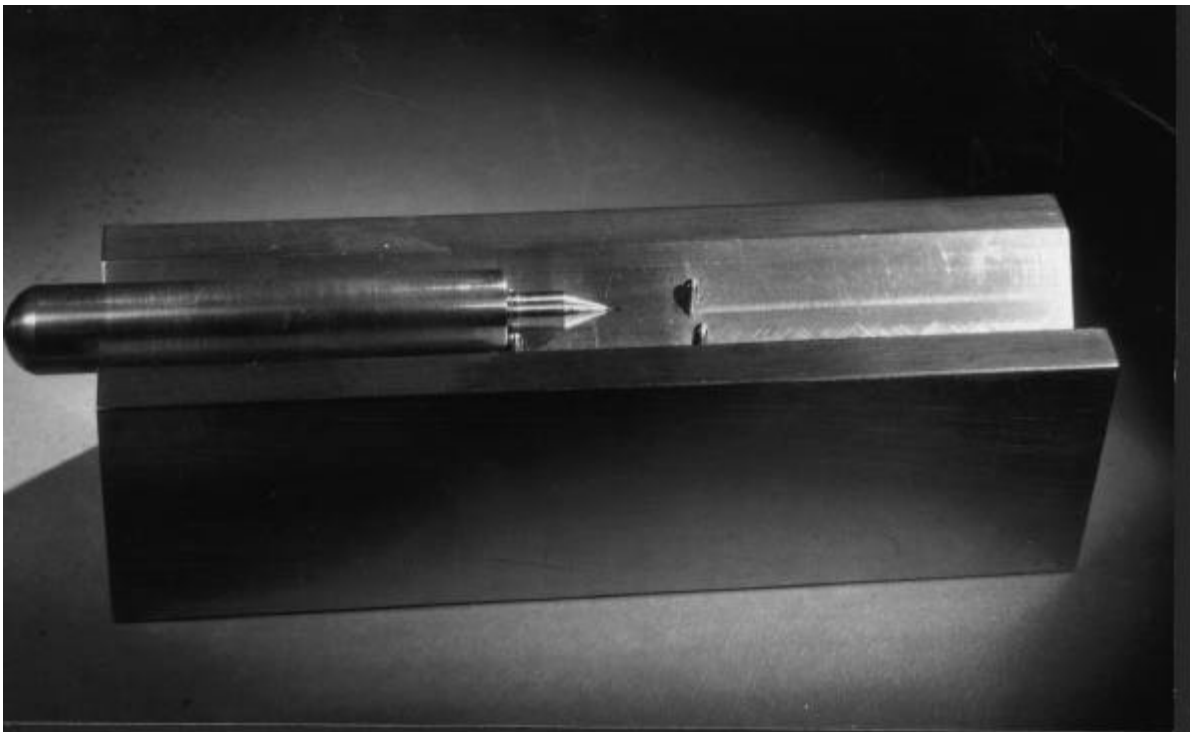
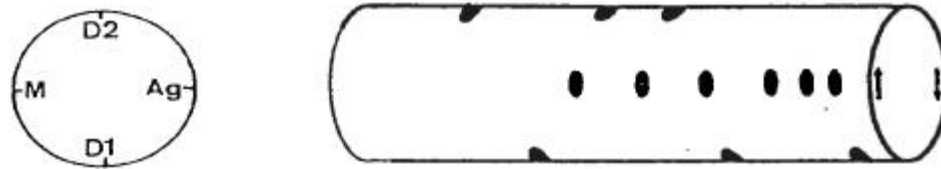


Figure 1. A binary Coded Wire Tag holder called a Reading Jig. The tag, held to the tip of the pointed device by magnetization, is rotated and read under magnification of about 10X.

The tags bear a binary code in the form of rows of marks along the long axis. These marks translate into numbers based upon their location within the code. The result is a series of code numbers which contain the data for the fish and the tagging agency. (see example in Figure 2).



	P	32	16	8	4	2	1
Master	0	0	1	1	1	1	1
Data 1	0	1	0	0	1	0	1=37
Agency	not visible in diagram						
Data 2	1	0	1	1	0	0	0=24

Figure 2. Diagram of the Standard CWT and the binary coding system. Proper orientation and rotational direction is indicated. In the table, a “1” indicates the presence of a mark and a “0” indicates the absence of a mark. The master row serves as the basis for tag orientation and can be recognized by the three crowded marks. Recognition of the master row is important because tags are rarely cut with an uninterrupted code (as shown here). More often, part of the code will be on either end of the tag. The “P” (parity) column serves as a check for code recognition and a mark in this column adds no numeric value to the code number. There must always be an odd number of marks counted in one row. If the numeric code is represented by an even number of marks, a mark will be present in the "P" column to ensure proper counting. In the example above, the "Data 1" row has marks in the 1,4, and 32 columns, an odd number so no mark is needed in the "P" column. The "Data 2" row has marks in the 8 and 16 columns, an even number which makes the mark in the "P" column necessary.

Standard CWTs are typically used to identify groups or batches of fish, numbering in the thousands, with the same code. Standard CWTs have four code rows: the Master, Data 1 (D1), the Agency and Data 2 (D2). The code rows are identified by their consistent relationship to the Master. The Master is the same on all standard tags and can be immediately identified by its uniform series of six marks which includes a uniquely crowded series of three - the middle of which lies between the 1 and 2 columns -- allowing proper orientation of the tag. Once this is done, the other rows are in order as the tag is rolled over. Rows D1 and D2 bear the codes providing the information on the specimen.

Sequential CWTs differ from Standard CWTs by having six binary code rows: a Master, D1, D2, the Agency, Data 3 (D3), and Data 4 (D4). D1, D2, and the Agency convey the same information as in the standard CWT and are read the same. The Master for Sequential CWT serves the same function as the Master for the Standard CWT, but the code is unique to help differentiate the Sequential CWTs from other types of NMF Coded Wire Tags. D3 and D4 are the rows which convey special sequence codes and the technique for reading them is different from the Standard CWT. As explained in the next section, once code numbers are determined for D3 and D4, the actual sequence number can be derived from the table or with the aid of computer software supplied by NMT.

The information from the two seven-bit data fields of D3 and D4 can represent 10,000 sequence numbers and, for each agency code, there are 3,969 such sequences which can be distinguished by available combinations of D1 and D2.

Reading Sequential CWTs

The format of Sequential CWTs (Figure 3) was designed with two things in mind: 1) the tag injectors cut tags of uniform length but without regard to alignment of the code pattern, and 2) to ensure that cut tags contain a complete code, they are about 20% longer than one code pattern. As a result, more often than not the cut tag will bear part of one code pattern on one end, and part of the next pattern on the other end. The patterns are designed so that successive patterns differ by exactly one binary mark position. For this reason a table must be used after reading the tag to determine the actual sequence number. (The table is available as a DOS format computer program or in tabular form from NMT.)

Also, there is a possibility that the D3 or D4 positions at the opposite ends of the tag could be marked differently. The coding format insures that either choice can be made and the two choices will always correspond to two consecutive sequence numbers.

Because the tags are cut longer than the code pattern, some of the tag codes will inevitably be lost. When tagging individuals, a code may or may not be lost, so the starting and ending sequence numbers may differ by either 2 or 3 depending on how the injector happens to cut the wire.

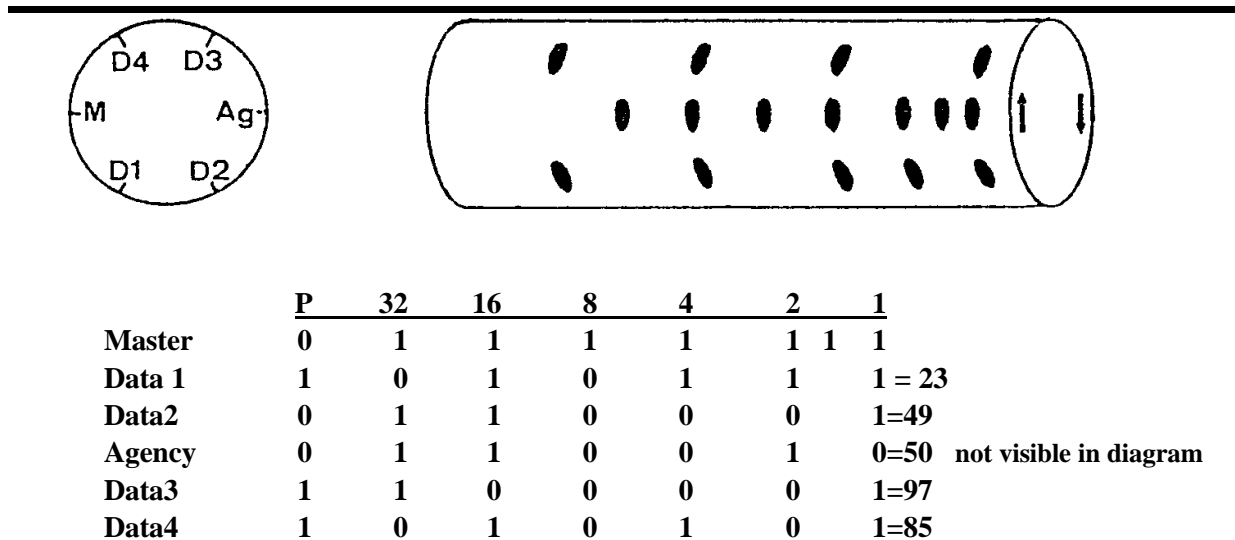


Figure 3. Diagram of a Sequential CWT and the binary coding system. The master row is recognized by the same three crowded marks as the standard CWT, but a mark in the 32 column of the master row identifies it as a sequentially coded tag. The "P" column serves the same purpose as in standard CWT for the D1, D2, and agency rows, but must be counted differently for D3 and D4. In the D3 and D4 rows, the "P" column represents a numeric value of 64 and the number of marks per row is not always odd.

Once the D3 and D4 code numbers are determined, the table (a page from which is attached) must be consulted to determine the sequence number. The table has columns labeled with Data 3 values and rows labeled with Data 4 values. The D3/D4 pair from the example above in Figure 3, 97/85, is found on page 27 of the table and represents sequence number 8345, (see example 1 on the table). The PC software (DOS format) allows the user to enter a D3/D4 pair and the computer then determines the sequence number.

Methods for Filing Sequential CWTs

Use of Sequential CWTs requires saving and filing reference tags in order to accurately interpret tags recovered from fish. This is necessary because the tags are cut without regard to the alignment of the code pattern.

Filing two tags, one immediately before and one immediately after the implant, is required for identifying individuals with 1.0 mm tags. This is a three-tag sequence -- file tag, implant tag, file tag -- and then the sequence is repeated, as shown below (note that there are two filed tags between any but the last implant): file tag/implant tag/file tag/file tag/implant tag/file tag/file tag/implant tag/

Similarly, only two reference tags are required to identify a specific *group* of fish as shown below: file tag/implant one tag per fish in the group/file tag/file tag/implant one tag per fish in the group/file tag/

Use of 1.5 mm tags simplifies the process by requiring only one reference tag per implant. This can be either the tag before or the tag after the implant tag, provided the sequence is consistent throughout the tagging process.

The importance of maintaining proper order during application cannot be stressed enough. The tagger and data recorder must maintain a high level of concentration and coordination. If one step in the application procedure is skipped and not corrected, much of the following data can be lost or useless. It is beneficial for the tagger and data recorder to confer regularly to assure that they are on the same line of data.

Various techniques are available for storing reference tags including tape, glass/plastic vials, small envelopes, etc. *Unerring organization of reference tags at the time of application is required.* Reference tags can also be stored in silicone strips that are adhered to sheets of waterproof paper available from NMT. The tags are easily injected into the silicone and are visible and secure. One form is used for tagging individual fish, (fig. 4), and another form is more convenient when tagging small groups of fish, (fig. 5).

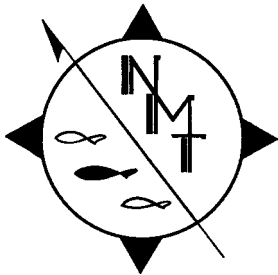
A complication arises when attempting to use this tag filing method with head molds commonly used for tagging salmonids: silicone strips don't fit. An option is to use a needle support tube in place of a head mold. Although additional care must be taken to properly locate implants, this method is convenient for filing, and has been remarkably efficient with various species.

Identifying the Specimen in the Data

Here is an example of how the process works for the identification of an individual specimen:

The reference tags on the silicone strips can be read at any time while waiting for the recovery of tagged specimens. The tags are easily removed from the silicone strip with a scalpel or sharp knife. A magnet is beneficial to have at hand while reading tags in case one is dropped. All the reference tags need not be read at this time - read only the first and last pair of each Strip so that a range of sequence numbers can be defined for that strip.

The recovered tags are temporarily stored in a manner to prevent loss of the tag and to prevent disassociation of information that was collected pertaining to the specimen. Once the recovered tags sequence number is determined, the correct reference strip can easily be found. The proper placement on the reference strip corresponds to the exact line of original data for that specimen.



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Fig. 5

SEQUENTIAL CWT REFERENCE TAG STORAGE SHEET FOR MARKING OF SMALL GROUPS

Location _____ Project No./Name _____ Operator _____
 Log Sheet No. _____ of _____ Agency _____ Data 1 _____ Data 2 _____

Date	Batch No.	Batch Size	Description	D-3	D-4	Seq. No.	First Tag	Last Tag	D-3	D-4	Seq. No.	Notes

Comments _____

Table of sequence numbers for individually marked tags. Page 27

D4\D3	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
64	8319	8320	8576	8575	9088	9087	8831	8832	10112	10111	9855	9856	9343	9344	9600	9599
65	8318	8321	8577	8574	9089	9086	8830	8833	10113	10110	9854	9857	9342	9345	9601	9598
66	8316	8323	8579	8572	9091	9084	8828	8835	10115	10108	9852	9859	9340	9347	9603	9596
67	8317	8322	8578	8573	9090	9085	8829	8834	10114	10109	9853	9858	9341	9346	9602	9597
68	8312	8327	8583	8568	9095	9080	8824	8839	10119	10104	9848	9863	9336	9351	9607	9592
69	8313	8326	8582	8569	9094	9081	8825	8838	10118	10105	9849	9862	9337	9350	9606	9593
70	8315	8324	8580	8571	9092	9083	8827	8836	10116	10107	9851	9860	9339	9348	9604	9595
71	8314	8325	8581	8570	9093	9082	8826	8837	10117	10106	9850	9861	9338	9349	9605	9594
72	8304	8335	8591	8560	9103	9072	8816	8847	10127	10096	9840	9871	9328	9359	9615	9584
73	8305	8334	8590	8561	9102	9073	8817	8846	10126	10097	9841	9870	9329	9358	9614	9585
74	8307	8332	8588	8563	9100	9075	8819	8844	10124	10099	9843	9868	9331	9356	9612	9587
75	8306	8333	8589	8562	9101	9074	8818	8845	10125	10098	9842	9869	9330	9357	9613	9586
76	8311	8328	8584	8567	9096	9079	8823	8840	10120	10103	9847	9864	9335	9352	9608	9591
77	8310	8329	8585	8566	9097	9078	8822	8841	10121	10102	9846	9865	9334	9353	9609	9590
78	8308	8331	8587	8564	9099	9076	8820	8843	10123	10100	9844	9867	9332	9355	9611	9588
79	8309	8330	8586	8565	9098	9077	8821	8842	10122	10101	9845	9866	9333	9354	9610	9589
80	8288	8351	8607	8544	9119	9056	8800	8863	10143	10080	9824	9887	9312	9375	9631	9568
81	8289	8350	8606	8545	9118	9057	8801	8862	10142	10081	9825	9886	9313	9374	9630	9569
82	8291	8348	8604	8547	9116	9059	8803	8860	10140	10083	9827	9884	9315	9372	9628	9571
83	8290	8349	8605	8546	9117	9058	8802	8861	10141	80082	9826	9885	9314	9373	9629	9570
84	8295	8344	8600	8551	9112	9063	8807	8856	10136	80087	9831	9880	9319	9368	9624	9575
85	8294	8345	8601	8550	9113	9062	8806	8857	10137	10086	9830	9881	9318	9369	9625	9574
86	8292	8347	8603	8548	9115	9060	8804	8859	10139	10084	9828	9883	9316	9371	9627	9572
87	8293	8346	8602	8549	9114	9061	8805	8858	10138	10085	9829	9882	9317	9370	9626	9573
88	8303	8336	8592	8559	9104	9071	8815	8848	10128	10095	9839	9872	9327	9360	9616	9583

Example 1. Table of Sequence Numbers – D3 values represent the columns and D4 values the rows. For D3 = 97 and D4 = 85, the sequence number is 8345. This example represents one page of a 32 page table.