ASME N510 TESTING OF NON-N509 SYSTEMS

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ABSTRACT

In recent years the question of what to do when faced with the task of performing a test series per ASME N510 on a Nuclear Air Treatment System that does not meet the requirements of ASME N509 has become a very common subject of discussion. Unfortunately, no one has presented a definitive resolution to the question. A number of papers have been presented at earlier conferences discussing approaches to specific systems or system designs. While they have been helpful, they have not addressed the general problem. The vast majority of HEPA filtration systems, with or without adsorbers involved, are not built to N509. Is there a systematic approach to use when faced with the requirement of performing N510 testing to these systems? That is the critical question that this paper will address.

This paper will review the basic technical situation of what the real problems are when trying to use N510 as the formal standard to test a non-N509 NATS. This basic question has not been addressed and is critical to arriving at a technically acceptable answer. Both N509 and N510 have always been written to be used as complementary documents. Each clearly states that they are to be used together with the same editions applying to each other. This is one of the most important points usually lost when regulatory compliance pressure is involved. ASME N510 clearly states it is to be rigorously applied only to NATS built to the same edition of N509. Since so called "verbatim compliance" is being enforced, this section of the Standard must be given equal weight as the rest of the Standard. This paper will analyze the Standard's application and offer guidance for *technical compliance with the INTENT of N510* when verbatim compliance is physically impossible.

For the purposes of this paper, the term "non-N509" systems is used to mean only those attributes that relate to N510 testing. Such noncompliance as material specifications, welding or QA qualifications or seismic design are not included in the scope of this paper. Only the design, fabrication and conditions of the system that effect the testability are covered in this paper.

I. Introduction

One of the most common and troublesome questions that exists for those who are responsible for Nuclear Air Treatment Systems (NATS) is how to test systems that were not built to the requirements of ASME N-509, "Nuclear Power Plant Air-Cleaning Units and Components" [1] to ASME N-510 "Testing of Nuclear Air Treatment Systems." [2] Since the vast majority of systems have not been designed and built with any reference to any edition of N-509, much less to the letter of the Standard, this question has great significance to the industry. The regulation of DOE facilities is being taken over by the NRC. Until recent years, DOE and DOD facilities had not generally used the ASME Nuclear Power Codes & Standards, so it is only the rare NATS that was built to them. With the increasing NRC regulation, the requirements for use of the ASME Nuclear Power Codes & Standards is becoming common and may become universal. However, even in nuclear power plants historically regulated by the NRC, there are many NATS that were not designed and built to N509.

This problem has been significantly accentuated by the NRC policy of "verbatim compliance." This policy requires NRC regulators to enforce licence requirements and licencee commitments VERBATIM without room for engineering judgement or reasonable acceptance of the problems of less than perfectly worded requirements. Therefore, when a requirement to perform a test "per N510" is stated, the regulator is requiring absolute "to the exact letter of the Standard" compliance.

This means that there are increasing situations where a regulation requires a NATS not designed or built to N-509 be tested to N-510. The question of which edition of these standards to use will be addressed later. The intent of this paper is to provide some general procedural guidance for those faced with this question. There have been a number of directly relevant papers presented at past conferences that give accounts of how specific systems were tested in a particular situation, or generally discussing testing of pre-N509 systems [3 through 30]. These are very helpful as anecdotal background but have not addressed the general procedural aspects of the problem. There are also many additional papers in earlier conferences that provide excellent background for NATS testing but are too numerous to list here. Review of the unique body of experience contained in the conferences is one of the best sources of education on NATS testing, and indeed all aspects of NATS technology. Your particular attention is called to the fact that the discussions that follow the actual papers in the Proceedings are often as valuable as the papers themselves.

II. What Is the Problem

The problem in being mandated to test a system per the requirements of N-510 that has not been designed and built to the letter of N-509 is that ***it is impossible to do—by definition***. The "Scope" (Section 1) of N-510-1989 states "This Standard covers the testing of ASME N509-1989 high efficiency air treatment systems for nuclear power plants." The "Limitations of This Standard" (Section 1.2) states in part "This Standard ***SHALL*** (emphasis added) be applied in its entirety to systems designed and built to ASME N509 specifications." Similar statements are in all earlier editions of N510. The ASME "Committee On Nuclear Air and Gas Treatment" (CONAGT) Committee that is responsible for these Standards has specifically written these Scope and Limitation Sections as carefully as possible to indicate the intent of N510 is that it only be applied to NATS designed and built to the corresponding edition of N509. I state this as a founding member of CONAGT and the chairman of the Testing Subcommittee for over a decade. I have been a member of the CONAGT Main Committee for over two decades. Given the considerable misuse of N510 by requiring it be used to the letter on non-N509 systems we have obviously not been successful. The Limitation Section states that sections of N510 " ***...MAY*** (emphasis added) be used for technical guidance for testing air treatment systems designed to other criteria." Note the difference between the imperative "SHALL" and permissive "MAY." In Codes and Standards "SHALL" means that something is mandatory, "MAY" only indicates it is permissible.

Bureaucratic or regulatory mandates that permissive technical action be mandatory are the basis of the problems discussed in this paper and suffered by much of the industry. If tests are not technically or physically possible then "mandates," from whatever source, do not somehow magically make them possible. Of course, physical modifications may be made to the subject systems to bring them into compliance with N509. This is often the best answer to the conundrum but neither an easy nor inexpensive one.

So the "problem" is: being asked to perform tests using a standard that is being incorrectly strictly invoked (ie. verbatim compliance) on a system not designed or built to the required companion standard. The only formal "verbatim compliance" answer to the "problem" is that—**"It is impossible to perform the requested test, *by definition.*"**

Unless the basic impossibility of testing a non-N509 system to the letter of N510 is recognized, all further efforts become muddled and usually more an exercise in futile paperwork than technology. This is the first, and most important, point of this paper. This exercise in logic may seem trivial or silly, but it is actually the critical first step in solving the real technical problem of how to obtain accurate data on the condition and performance of the subject system.

A related, and equally critical, point is that "testing per ASME N-510" ONLY results in test data, hopefully accurate. It does NOT mean "passing the system." Many combine the ideas of obtaining data using N510, or any other standard method, with obtaining results that successfully meet whatever criteria has been set for the system. Again, this is a critical concept that must always be kept in mind when performing any test. First comes the data, then evaluation of the data, then some decision on the meaning of the data and last, what, if any, actions must be taken based on this evaluated data. This concept is the second critical point of this paper.

One interesting parenthetical point: if a non-N509 system is modified to such an extent that it can be tested to the letter of N510 **then for the purposes of N510 testing, IT IS AN N509 SYSTEM**.

III. Discussion of the Real World Alternatives

The objective of any test is to obtain as accurate data as possible to allow evaluation of the item or system under test. This basic fact is sometimes lost and the reason for the test is incorrectly believed to be to meet some bureaucratic requirement. Certainly the bureaucratic requirement will often exist, but all anyone who is performing the test, any test, can do is provide data of defined accuracy and precision. ASME Standard N510 has been developed and revised by industry experts for over twenty years and provides methods that, when properly followed, allow accurate data to be obtained. This does not mean that the methods in N510 are the only ones that produce accurate data or that valuable data may not be obtained using variations of the N510 methods, or other methods entirely. This idea is another important point of this paper.

What are the TECHNICAL alternatives to using N510 strictly? Clearly the methods specified in N510 may be used as technical guides, as the Limitations Section of N510 specifically states. The question is, how accurate are the data obtained using other than strict N510 methods and how does any inaccuracy impact evaluation of the system being tested? Unfortunately, this is not an easy question to address since the range of physical systems that may be tested or asked to be tested is extreme. Often quite reasonable data can be obtained for evaluation. On the other extreme, some systems simply have no provision to allow any meaningful data to be obtained without physical modifications being performed to the system. Between these extremes my experience has shown there is a full continuum of possibilities.

The best approach is always to try to modify the system to allow strict N510 test methods to be used. For new systems being acceptance tested or systems that are not contaminated and are in accessible areas, such modifications are often possible, and should be made. For the majority of systems this is not practicable since they are contaminated, in contaminated areas or can not easily be taken out of service. Often it is for all three of these reasons. Of course, a fourth reason the modification route is not taken is budget. The budget reason for rejecting modifications quite often results in the highest overall cost since the total expenditures of trying to justify incorrect test methods, many retests, later modifications or fines can far exceed the cost of up-front modifications to do it correctly the first time. The idea of not being able to do it correctly the first time, but having the time and money do "do it over" is not unique to this problem area.

From an engineering point of view, what are the important parameters that are necessary to evaluate a Nuclear Air Treatment System? For system functionality they are; leak tightness of the housing, air flow capacity, developed pressure (positive or negative), air flow balance, pressure drop across the filter/adsorber banks, filter/adsorber bank leak tightness, system leak tightness and the condition of the filters and adsorbents, if any. As you can see, these are very close to the basic sections of N510. Some other parameters are included in N510 such as heater electrical checks and performance for humidity control, but since this component is used mainly in NRC licensed nuclear power plants where the testability has been largely met, it is not covered in this paper. Heater electrical checks and air flow temperature measurements are seldom a problem to conduct adequately. The vast majority of non-509 NATS are in DOE facilities where only HEPA filters are used. Some systems do have adsorber sections so this area will be included for discussion.

Prefilters, moisture separators, heaters, and cooling coils are other common NATS components. The easiest way to check prefilters and moisture separators is visually and by measuring the pressure drop across them. Hopefully there will be pressure drop measuring instruments as a part of the system. If not, it is simple to use a manometer unless the system is highly contaminated. Visual inspection may be easy using built in view ports, or totally impossible. Without view ports the system must be opened, which may not be possible if the system is contaminated. This greatly increases the difficulty of determining the status of the system components' condition. The value of visual inspection must never be overlooked.

When evaluating pressure drop across a component bank, do not fall into the trap of believing a very low differential pressure is always good. A differential pressure across a component bank that is less than that of newly installed clean components may indicate the components have failed and are no longer performing any positive function. Worse, failure of prefilters may mean the following component bank has been blinded with the prefilter material and has either also failed or simply increased the differential pressure across it to the point the system airflow is unacceptably low. Common sense and experience are always the most valuable tools at your disposal.

The technical and radiologically (or chemically or biologically, or some combination of these three, depending on the purpose of the system) significant criteria of the housing leak test depends on a combination of basic design factors. Is the system positive or negative in pressure compared to the area in which it is sited? Is the area in which it is sited clean or contaminated? ASME N509-89, Appendix B provides an excellent table showing the various configurations and discussion of how to calculate the leakages in both housings and related duct work.

This is an appropriate time to stress the importance of the interrelationship between N509 and N510. Each was written to be the companion of the other. They are written to be used together in the same editions. That is N510-75 & N509-76, N510-80 & N509-80 and N510-89 & N509-89 are equal siblings and must be used together. N509 defines hardware that will be designed and built to be testable to N510. N509 requires factory testing that in part is the same as in-place testing required by N510. N510 tests are performed to provide data that will be evaluated to determine if the requirements of N509 design and performance objectives have been met as the system is installed. While there is merit to upgrade to some of the testing methods in N510-89 from earlier editions, great care must be taken to review each section of the standard to be upgraded to be certain that the new requirements can be met with the existing hardware designed and built to the earlier edition of N509. Particular caution is necessary for the laboratory testing of the adsorbent.

I will not repeat the discussion in Appendix B of N509 except to say that there is a critical difference to evaluating the significance of housing leakage depending whether the leakage will result in contaminated air flow to areas where it is not wanted. There will, in many systems, be leak paths that do not result in this problem. Small leakage into a system from a clean environment is obviously not a serious problem, whereas leakage into a control room system after the filter banks from a contaminated environment is a serious problem. Investigation of this attribute is obviously the first step in the technical review necessary as preparation for writing a housing leak test procedure for a non-N509 system. Unless you know what the critical parts of the housing are, it is impossible to know if meaningful testing will be possible.

Let me use this as a general example for evaluating the significance of NATS testing of non-N509 systems. Since by definition it is impossible to perform an N510 test to the letter of N510, we need to know the significance of the data we are able to obtain from other testing methods, and how it impacts the performance of the subject system. Purposely repeating myself we, *by definition*, are not able to perform the desired/required test, so we must make technical judgements on what tests are physically possible and of what value the data obtained will be to evaluate the system performance. This point can not be stressed too strongly. **We are making engineering judgements based on imperfect data in an imperfect world. Regulations and other edicts can not change this FACT.** If no other point remains in your mind from this paper, this is the most critical single one I am trying to make.

How do we leak test a housing? If we could test it per N510 we would not be discussing it here. Probably the housing is installed and possibly contaminated. We will assume it can not be blanked off for a pressure decay test so we will look to other methods of determining leak tightness. The very best way to always start any test is with a detailed and extensive visual test. Usually the outside of a housing is accessible or at least visible. Look for leak paths, holes, open instrument tubing, open piping, floor drains, etc. The "Guidance for Visual Inspection" section of N510 is a starting point, but experience is the best preparation.

While doing a visual inspection listen for leaks. Air flowing through small holes makes noise. The author has found may leaks this way. After these methods have located any leaks, they should be repaired. For positive pressure housings, you can use the leakage from the inside to the outside to find itself if some harmless contaminant is able to be detected by an instrument. This contaminant may be one normally in the air flow or one such as DOP introduced for the test. Scan the outside of the housing for the contaminant and locate and quantify the leakage.

Obviously if there are dangerous contaminants leaking from the housing, other immediate safety actions have presumably been required as soon as the leakage was discovered. Negative pressure systems are more difficult to test but a similar method is possible. Scan the outside of the housing with a source of some detectable gas such as a halide and measure the concentration inside. This is a time consuming test but can provide excellent data when performed carefully. These methods should provide reasonably reliable, if largely qualitative, data of the housing leakage. In cases where the housing is not at all accessible, testing may not be possible at all.

The next step in testing is the leak tightness of the HEPA and/or adsorber banks. This means leak testing each of these banks individually. To perform such tests the N510 prerequisites must be performed. These are air flow distribution and challenge/air mixing. These tests are necessary to provide the basis for accurate filter bank leak tests. Unless we know the way the air is flowing through the banks, it is impossible to obtain accurate data on the challenge/air mixing and, therefore, the accurate leakage through the component bank.

The first step is to find the original testing reports, if any, to see if this test has been performed. If you are lucky and it was performed, the air flow distribution should not have changed unless the system was modified or there is extremely uneven loading of some filter bank sufficient to change the airflow distribution. Most probably, if it is a non-N509 system, no airflow distribution test was ever performed. The only way to obtain air flow distribution data is to measure the air flow velocity over the face of the component bank. This can be accomplished with pitot tube traverses or by using any other instrument that can be inserted into the system that measures air flow velocity. The profile must be taken as close to the component bank as possible since the profile can change significantly in short distances if there is anything near that disturbs the air flow. This measurement requires access inside the housing. If such access is not possible the test is not possible. When this is the case and modifications can not be made to allow access, we must move on to the next test, clearly understanding the data taken for the challenge/air mixing and actual leak test will be compromised. It is unfortunate that we are forced to perform tests that we know will produce compromised data, but it is still possible to obtain valuable information from such tests as long as the data is properly understood and evaluated.

The next prerequisite test is the challenge/air mixing test. This test confirms that the challenge introduced to evaluate the leak tightness of the filter or adsorber back is sufficiently even across the face of the bank that single point samples taken upstream and downstream are representative of the entire bank. The test is usually conducted with DOP aerosol and the standard aerosol detector is used to measure the relative concentration across the face of the filter bank. First look for previous tests, since the mixing will not change unless the system has been modified or the injection point has been changed. An injection point is chosen upstream of the bank where it is hoped that sufficient mixing will occur before the challenge reaches the bank under test, and the concentrations measured in front of the bank. Other than the fact we are measuring aerosol concentration, the same situation exists as described above for the air flow uniformity test. We must have access through the housing for the test. Again, if no access is possible we further compromise the actual leak test. But as with the airflow distribution test, it is still possible to obtain some information about the filter bank leakage, without the challenge mixing test it is impossible to perform the mixing test.

So far in this discussion, testing (injection or sampling) manifolds have not been mentioned. If the system is pre-N509 or otherwise non-N509 there are probably no manifolds. Since a well designed manifold will, in nearly all cases, improve the challenge/air mixing, adding a manifold to improve mixing is highly recommended when no data can be obtained about the existing mixing without the manifold. This addition can only help even if no data can be taken to prove the statement. It will certainly help increase confidence in the actual leak test. N509-89 includes excellent discussion and design information for these manifolds and is highly recommended.

The actual leak test is the heart of the exercise to evaluate the performance of a NATS. If contamination leaks past the filters or adsorbers, the system is not performing the task for which it was built. The worst way to find a system leaks is by the contamination that is leaking past the filters making itself known by some adverse effect. Preventing this is the real reason we are testing the system. This is another critical point of this paper.

Leak tests of filter and adsorber banks all are the same in concept. We measure the concentration of something upstream of the bank, then downstream of the bank, and compare the results. If the leakage is low, less of what we are measuring gets through the filters or adsorbers. Everything else is simply to ensure the data is accurate, precise and repeatable. If an artificial challenge is used it ONLY gives a "figure of merit" NOT the actual efficiency of the bank in a real world challenge. All the standards and regulations are based on artificial challenge and provide some figure of merit, not the actual efficiency in real world use. It is possible to use real challenge, but in the U.S. this is not done. For example, some other countries use methyl iodide 131 as the challenge for adsorbers. This is the contaminant of interest, so the efficiency obtained from upstream and downstream measurements is real for that level of loading. Remember the real world is not composed of 0.3 micrometer aerosol or halide challenge gas.

When the system does not allow access so neither air flow distribution nor challenge/air mixing tests are possible, using the actual components of the operating system as the test challenge is the best approach. To do this there must be sufficient upstream loading of what is planned to be measured to allow the instrument range and sensitivity to provide the necessary range for whatever level of leak tightness is being required to be calculated. Since the usual requirement is 99.95% leak tightness, a range of at least 10,000 is necessary. The component measured may be particulates or some radioactive component. Since the most common reason that access is denied is radioactive contamination there is a reasonable chance there is sufficient radioactive loading to allow the test to be based on measurements of activity upstream and downstream. The linear range of most measurements of radioactivity is usually well over 10,000, so this can be an excellent test method.

When an artificial challenge is required to be added, it must be as well mixed as possible both before and after the bank under test, hence the challenge/air mixing tests. The use of injection manifolds is usually helpful but it may be possible to inject the challenge far enough upstream that mixing will be sufficient. When no challenge/air mixing test is possible, always err on the conservative side and use a manifold to ensure the best possible mixing from the injection point. There MUST be an upstream sample taken before the filter bank being tested. This requires at least a small hole in the housing to take the sample. This MUST be done. No meaningful test is possible without the sample. Some say generators can be calibrated with sufficient accuracy and repeatability to allow a meaningful test without an upstream sample. This may be true under ideal conditions, but when we are faced with the already large compromises of no airflow distribution or challenge /air mixing tests, the upstream sample is mandatory for a quantitative test. Certainly if it is absolutely impossible to take the upstream sample a "calibrated" challenge generator can provide some qualitative information about the system, but such a test can not be really defended as quantitative in my experience and opinion.

For the downstream sample we have the mixing problem in reverse. Leaks are usually extremely local, so for a single sample to be representative of the entire filter bank, the leaking challenge must be very well mixed with the other filtered air. Usually a fan will provide this mixing so taking the sample after a fan is a good point if nothing is between the filter bank and sample that will change the challenge concentration. This means only the final HEPA bank before a fan can be tested using the fan to provide the downstream sample mixing. Multiple HEPA banks in series are very difficult to test without well designed and installed manifolds that have been factory tested. For pre- or non-N509 systems this is never the case. Reference 29 provides some background and suggestions for this problem. There is no easy answer. Multiple HEPA banks without fully factory tested manifolds may not be testable when they are contaminated to the extent entry for scanning or multiple sampling is not possible. As stated in the beginning of this paper, there are times when the physical limits of the system prevent N510 type quantitative tests to be performed no matter what the regulations or edicts are.

When the best possible injection and sampling facilities are determined and whatever manifolds have been designed and constructed, a filter bank leak test should be performed. At this point one of the most important steps is to fully document exactly what has been done. Prepare detailed sketches of the exact locations of the injection and test ports, detailed drawings of the manifold and exactly how they have been installed and list all the known parameters of the system operation during the test. Document airflow, all known system pressure drops, the exact configuration of the system and all dampers and anything else that may have an effect on the system airflow or airflow distribution. Of course this is only what every test should have for documentation, but for "custom tested" it is even more critical. Usually the system mode preferred for testing is the standard operating mode, since it will provide data closest to that which will be encountered during this normal system operation. If some other mode is used for testing, another significant unknown is being added to an already difficult situation for evaluation. Always try to eliminate anything that deviates from normal system operation. If there is more than one operating mode, the "custom test" should be performed for each operating mode.

How is the data obtained for these filter/adsorber bank leak tests evaluated? This is a difficult question since we know we have significant unknowns if the airflow distribution and/or challenge mixing tests could not be performed or if the samples were taken from positions not formally confirmed as fully representative. There are probably additional unknowns we are not even aware of for old systems without full drawing and documentation packages. Our data can show leakages of from "none detectable" to extreme, but with all the unknowns, what does this data mean? Does it represent the actual system condition or is it simply some artifact of our best effort test setup? The strict answer is we will never know exactly but we can estimate some defensible information from the test results.

If we are confident of our injection and mixing based on the location we injected and from the use of a good manifold, we can be reasonably confident we challenged the bank properly. Given a well mixed challenge our upstream sample should be good, if we have carefully investigated the system to be certain no ducts brought other air to the bank that did not contain challenge, that the sample was not taken behind some structure that shielded it from taking a representative sample and that there was nothing after the sample point that would reduce the concentration of the challenge such as prefilters.

The final critical input to the leak calculation is the downstream sample and it is often the most difficult if there are multiple filters in series. Taking the easy situation first, if the sample was taken after the filter bank and downstream far enough in the duct that good mixing may be inferred or, if a sample manifold was used, or if the air passed through a fan, the sample should be representative. Of course there are the usual cautions about samples taken after a fan. Did air leak into the fan through shaft seals or other housing leaks? Was this air dirty to produce a false high leakage calculation? Was the in-leakage clean, but of such a volume that it dilutes the sample for a false low leakage calculation? If these evaluations can indicate confidence that the injection of challenge and taking of samples were technically defensible then the leakage calculated can also be ***technically*** defended. Note I stress the word "technically." This test, no matter how accurate the calculated leakage may actually be, is not an N510 test. The system was not built to N509 and letter of the N510 testing Standard was not met so it could not, ***by definition***, be an N510 test. This may seem a small point but legally it is critical. Do not let yourself be pushed into claiming an N510 test was performed when it was not, and could not have been, performed. What was performed was a test ***"to the intent of N510"*** to the extent physically possible. This is what the ASME CONAGT committee that wrote N510 intended and wrote into the Standard for situations where the system is not an N509 system.

The idea of insisting on the system being in the normal operating mode was stressed above. One of the main reasons for this is that the test leakage measured will be closest to that encountered during the actual system operation. This may sound as if only stating the obvious but there is a subtlety involved. Even if the test misses challenging some part of the filter bank and the injection mixing was good, the bank probably does not have significant airflow at the points missed. Since obtaining good mixing by the use of injection manifolds is usually possible, and obtaining good downstream samples for single HEPA banks is usually possible, the unknown of the actual challenge agent covering the entire filter bank and bank/wall interface becomes less important if the actual operating mode is used for the test.

The most difficult HEPA filter bank testing situation is when there are multiple HEPA filter banks in series. Realistically it is doubtful that for systems without built-in testing manifolds that have been factory tested per N509 the HEPA banks can be individually tested. If full access is possible so scanning or multiple sampling techniques can be used, good individual bank tests are possible—not to N510-89, but possible. For systems where access is not possible but penetrations from the sides or top allow multiple sampling to be used by insertion of sample tubes, good tests may be possible. If no access even through penetrations that allow the entire bank face including bank to wall interface is possible, then individual bank tests are not possible. No matter what the regulations or edicts say, if the data can not be obtained the test can not be performed.

The final test is for adsorber banks. These are not common in DOE facilities but are very common in DOD facilities. All the testing methods and cautions discussed for HEPA filter banks apply for adsorber banks. Halide gas leak testing has two major differences from DOP aerosol testing. The advantage is that, as a gas, the halide challenge can be injected upstream of all particulate filters and not be affected by them. This makes a good injection for challenge/air mixing relatively easy since the same proven injection port used for the first HEPA bank test can be used as a proven injection port for the first adsorber bank. The additional complication is that the halide gas challenge is only delayed by the adsorbers, not stopped as DOP aerosol is by HEPA filters. This means that after each test the halide challenge must be desorbed from the adsorber banks before a retest is possible. Series adsorbers require the challenge from the first bank to be desorbed from the second before the second bank can be tested. The testing of series adsorbers is complex even for strict N509 systems. A detailed discussion of how to accomplish a good individual bank test for series adsorbers will require more depth than is practical here. Fortunately except for some specific military facilities, they are rare and new enough to have the necessary testing manifolds built in.

IV. Summary

In summary the critical points of this paper are:

1. Strict N510 testing of non-N509 systems is impossible by definition as is explicitly stated in all editions of N510.

2. Testing does not "pass" systems. Testing, at best, can only provide accurate data for evaluation.

3. Can technically defensible N510 type tests be performed on non-N509 systems? Sometimes, but often it is simply not possible. If such is the case then there is no defensible method to determine if any credit can be taken for the system.

4. Testing methods that are variations of N510 methods, or other methods entirely, can produce accurate data if properly developed and carried out. This is explicitly permitted by N510 when it is used for technical guidance.

5. Always try to permanently modify the system to be testable to the maximum extent possible as the best long term approach when encountering a non-N509 system. It is the most cost effective in nearly all cases.

6. The three existing editions of the related N509 and N510 Standards were written to be used as corresponding pairs. Care must be exercised when changing the reference to the N510 testing document making it a different edition from the N509 design and fabrication document.

7. Careful and complete documentation of what non-standard tests are conducted can never be too detailed. Always think of the new person who must perform the next test when writing about how you performed the test.

8. Good engineering judgement and system testing experience is invaluable.

9. Simply shuffling paper can never change a bad design to a good design. Neither does simply writing justifications improve poor systems— it only perpetuates bad design and practice.

All of these points are simple, basic common sense and good engineering practice. However my experience has shown that they are all too often lost in the considerable pressures of meeting technical and regulatory requirements. I hope this paper may be of some assistance to those faced with these problems.

V. Addendum

The 1997 edition of ASME AG-1 "Code On Nuclear Air And Gas Treatment" has been published as this paper was being written. This 1997 edition of AG-1 contains Section TA "Field Testing of Air Treatment Systems." All the same cautions, exclusions and limitations apply to the use of this new testing Code Section as are discussed here for N510. ***Section TA of AG-1, 1997 applies ONLY to components and systems built to the 1997 edition of AG-1, BY DEFINITION.*** Therefore, Section TA, can be strictly applied ***ONLY*** to components and systems designed and built to the 1997 edition of AG-1. ***Any other strict use is, BY DEFINITION, incorrect.***

VI. References

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