What is the first step to the solution of a problem? Everyone should agree that the answer to this question is: recognition that a problem exists.

In the seed business, recognition that a problem exists is not as difficult as in some other industries since there are many people ready to tell us when we have a problem. Is there a seedsman who has never had a customer complain about the quality or performance of the seed he or she purchased? I don't know of any. In the seed industry, we even have professional problem identifiers. We call them seed control officials, or often other names when a stop sale or similar notice of violation is received in the morning mail.

Assistance in problem recognition is not limited only to the commercial operations of the seed industry. Seed control and certification officials are constantly reminded that they don't know what the h--- they are doing. Indeed those of us in the academic community are frequently informed that: the problem with you guys is that you (a) spend too much time overseas, (b) don't know what's going on in the "real" world, (c) are not conducting research concerning the right problems, or (d) don't give your students the proper training, etc.

In short, all of us probably have more than enough assistance in problem recognition. However, it is not often that those who quickly recognize our problems follow through with a comprehensive analysis of the cause or nature of the problem identified and then offer a workable solution to our problem. We can say - the problem with a problem is a problem.

Specifically, the purpose of this presentation is to identify some of the ways in which we can diagnose potential problems associated with conditioning seed and then arrive at a workable solution based upon this diagnosis. Keep in mind the information in this paper will not solve your problems. At best, the ideas presented will assist you in the diagnosis of your conditioning needs which will in turn permit you to reduce the chances of the problem occurring.

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What is seed conditioning? In the broad sense, it encompasses all of the activities involved in preparation of the harvested seed lot for marketing and planting. Specifically, conditioning a lot of seed may include drying, pre-cleaning preparation, cleaning, up-grading, size grading, treating and/or packaging.

We could develop a long list of reasons for conditioning seed but the most important reason is to increase sales volume and/or price. Unfortunately for those involved in conditioning operations, perfect conditioning of a seed lot doesn't directly assure increased sales. As with most other products from automobiles to video games, most seed lots are conditioned to meet the competition, not to beat the competition. Meeting, not beating, the competition is an economically rational managerial decision for nearly all organizations. The marketing or sales manager, as influenced by the competition and consumers, has the major role in establishing both the maximum and minimum quality levels of the seed to be sold.

On the one side, seed conditioners are constantly pressured to increase or maintain minimum quality levels set by quality control, certification and regulatory personnel. On the other side, management indicates that cleaning seed to 99% purity when only 98% purity is required is the same as giving away 1% of the gross sale price, which is often 10% or more of the net profit. Not too many conditioning plant managers have a salary equal to 1% of the company's gross sales.

It is not a great compliment to say that you have the capability to be a conditioning plant manager since nearly anyone can have this title. The real compliment is to say that you have the ability to manage a seed conditioning plant. Conditioning Manager is a title; managing a seed conditioning plant is an occupation. In some companies there is a great difference between the title and occupation but in successful companies they are the same.

Why do we condition seed? From a technical viewpoint there are six major reasons:

a. Remove inert matter, weed seed, other crop seed, undersized and damaged seed.

b. Improve the appearance and physiological quality of the seed lot.

c. Facilitate mechanical planting.

d. Increase the storage life (clean dry seed store better).

e. Apply pesticides.

f. Increase marketability (higher quality seed in an attractive package).
Most of us have heard the expression, "this is a problem lot", used at one time or another. Usually this phrase is based upon ignorance. All combine run seed lots are problem lots until they meet someone's quality standards. The conditioning of some lots requires a higher level of knowledge concerning the use of the people, equipment and money available than others. Thus, you may say to your boss, "I have a problem lot", but he may actually hear, "I don't know enough to condition this lot to make it saleable."

Don't develop the impression that every lot of seed can or should be conditioned to a level that will make it marketable. We all know better. Over time, every seed conditioner encounters a lot that cannot meet anyone's standards no matter how knowledgeable or talented he may be concerning seed conditioning. In such instances, the "problem" is not how to condition the seed, but what to do with a seed lot that cannot be conditioned to a marketable level and then making the decision before the seed are conditioned. As Conditioning Manager you are responsible for making the decision: to condition or not to condition, that is the question your diagnosis must answer. The difference between 1000 bushels of "junk seed" which belong to a producer and the resulting 800 bags of "cleaned junk seed" now owned by your company is likely to be your job.

In all seed conditioning operations, the ability to meet the desired quality standards is affected by four factors: (a) the equipment available, (b) the arrangement of the equipment within the plant, (c) the operator's skill in adjustment and operation of the equipment, and (d) the operator's knowledge of the seed lot's characteristics. Note, the first two of these four factors were fixed when the conditioning plant was built or remodeled. As a result, operational skills and knowledge of the seed lot's characteristics are the only two variables immediately available to conditioning plant managers or the management by which they can control seed quality. These are the human variables.

Let's now consider some of procedures and techniques that have proven effective in diagnosis of conditioning needs.

The Pre-Conditioning Diagnosis

If you believe the old adage, "If you've seen one, you've seen them all", please stay away from the conditioning plant. There are no two seed lots exactly alike. A representative sample of every truck load and/or lot of seed to be conditioned should be examined before it enters the conditioning plant. We refer to any and all evaluations made of a seed lot after it is harvested, but before cleaning, as pre-conditioning diagnosis.
PRE-CONDITIONING DIAGNOSIS

*DETERMINE SEED MOISTURE

*DIFFERENCES IN PHYSICAL PROPERTIES OF GOOD SEED AND CONTAMINANTS

*VARIATION IN PHYSICAL PROPERTIES OF GOOD SEED

*RATE OF OCCURRENCE OF BAD CONTAMINANTS

*FLOW CHARACTERISTICS OF SEED MASS

*NEED FOR SPECIAL TREATMENT BEFORE CONDITIONING

*TYPES OF SEED DAMAGE

*HOMOGENITY OF SEED LOT
The purpose of the pre-conditioning diagnosis is two-fold: (a) to determine whether the seed lot should be conditioned, and if so, (b) to determine the separable components and special requirements for proper conditioning of the seed lot.

In diagnosing seed conditioning needs, there are at least eight separate factors for which the conditioning manager must make a determination. These are:

a. Seed moisture content.
b. Basic differences in physical characteristics of the seed and contaminating materials.
c. Variation in the physical characteristics of the good seed.
d. Frequency of occurrence of contaminants, especially the most undesirable ones.
e. Flow characteristics of the seed mass.
f. Need for special pre-cleaning conditioning.
g. Damaged seed.
h. Lot homogeneity.

The order in which these factors are presented is not significant. Further, the relative importance of each factor depends upon the seed kind, the environment under which the seed were produced, and the quality standards which must be met.

Let's consider each of these factors and the techniques used in the diagnosis.

Moisture Content: Everyone should be aware of the importance of seed moisture content as it relates both to the keeping qualities of seed and susceptibility to mechanical injury during handling. Most corn and rice seed are harvested at high moisture contents and must be dried within hours after harvest. But how long to dry and at what air temperature and R.H. is dependent primarily upon the seed moisture content. Seeds of agronomic crops should generally be at less than 14% moisture before the seed cleaning operations are initiated.

Except for seed very high (above 28%) or very low (below 8%) in moisture content, an array of moisture testers are available with which this determination can be made quickly and accurately. In spite of the
importance of seed moisture content, many seedsmen never determine moisture content after the harvest rush begins. Except on the first roll, 7 is craps.

**Differences in Physical Characteristics:** A mechanical separation of good seed from its contaminants is possible only when there are mechanically distinguishable differences in one or more physical characteristics of the good seed and the contaminants. What is a mechanically distinguishable difference? The answer depends primarily upon the machines available and the operator's skill in running them. The effectiveness of a separation is related to the consistency of the difference and the feed rate.

There are eight primary physical characteristics by which mechanical separations can be effected. These are: gross size, length, width, thickness, shape, surface texture, weight (density), and color. Differences in electrical charge are useful in making some separations. Every seed and particle of contaminating material in a seed lot possesses all of these physical characteristics; therefore, it is the differences which make them separable.

Contaminants which have physical characteristics similar to those of good seed are of greatest concern. When examining the seed lot, particular emphasis must be placed on determining the presence of contaminants such as noxious weed seed, nematode galls, etc., which could cause the seed to be unusable even though the mechanical purity exceeds 99%. Seed of common weeds, other crops or varieties, damaged seed, and inert matter similar in physical characteristics to those of the good seed, are of descending importance in most seed lots.

Determination of the basic physical differences by which a particular separation can most effectively be made requires: a knowledge of the specific physical characteristics of the good seed and other contaminating materials. This requires at least a visual examination of the seed lot to be conditioned. Failure to make a visual diagnosis of every lot which enters the conditioning plant is an open invitation to the unemployment line.

Ideally, the conditioning manager will have an opportunity to "test" clean each lot of seed with hand screens and model equipment. This permits a precise diagnosis concerning what contaminants can and cannot be separated and an estimate of the clean seed loss required to remove the contaminating materials. The results of a standard purity analysis do not provide the needed information for determining physical differences among the good seed and contaminants.
At the minimum, a representative sample should be spread on a well-lit floor or a desk top and examined to determine specific physical differences. Visual examination is not effective for determining minor differences in length, width, thickness, shape or surface texture and of very little value for determining differences in seed density.

Variation in Size of the Good Seed: This is one factor frequently overlooked when examining seed prior to conditioning. Research conducted in 1975 showed that the smallest seed in a lot are of little value for reproductive purposes. On the other hand, the research indicated that the exceptionally large seed, although nice in appearance, are also usually not the most desirable for reproductive purposes. Therefore, in seed, what we really want are those large enough to perform their function, but small enough to avoid problems due to their small size, i.e., immaturity.

For most crops, the better the environmental conditions for seed production, the more uniform the seed size. For all species, the more uniform the seed size, the easier the seed are to clean. Experienced conditioners know that different varieties of the same species often differ significantly in average seed size and they adjust the machines accordingly. One of the poorest testimonies to a seed processor is to utilize screens marked with the name of a crop. Except for size graded seed such as corn, such markings indicate a disregard for the natural variation in size and the other variable physical characteristics of the good seed in a seed lot.

An easy way to diagnose size variation in the good seed is to stack a continuous sequence of seven or eight hand screens and determine the size range of the good seed and contaminants. The shape of the screen perforations will depend upon the crop seed and contaminants but usually it is the same as the final grading screen. All good seed should pass through the top screen and no good seed should pass through the bottom screen of stack. Place a cupful of seed on the screens and shake. Unstack the screens and determine which screen has the most seed on it. The seed on this screen are of the mean size. For seed of many crops, a screen size two "sizes" below the mean is an appropriate size for use as the final grading screen. The largest perforation screen, on which only one or two very large seed remain, can often be used as the final scalping screen.

Yes, using this technique will increase the cleanout 1 - 3%. It will also improve appearance, the general seed quality level and simplify subsequent upgrading operations.

Frequency of Occurrence of Contaminants: This refers to the ratio between the good seed of a lot and undesirable materials. When examining the seed to be cleaned, you may identify several undesirable con-
taminants, i.e., weed seed, other crop seed, or inert matter, but it usually is the ratio of good seed to the contaminants that is most important, not the fact that contaminants are present. Depending upon the quality standards to which the seed must be raised, certain contaminants can be ignored. All clean seed will contain a fractional percentage of inert matter. Many lots of seed contain small amounts of other crop seed or common weed seed because the cost of removing these contaminants exceeds the value added by their removal.

As an example, if the pre-cleaning examination revealed the presence of an occasional oat seed in a lot of non-certified wheat seed, the occasional oat could be ignored. However, if the wheat seed were to be certified, it will be necessary to remove the oat seed. The presence of this oat seed would require the use of length grading equipment, therefore, increasing the cost of conditioning the certified seed. This same example is equally valid for common weed seed and inert matter, in that the quality standards set by management or, in some cases, by regulation determine what contaminants must be removed from each seed lot.

Although a visual examination will provide an estimate of the frequency of contamination, a detailed purity analysis is most useful for making this determination, particularly when a low frequency of noxious weed seed is involved. Identifying one johnsongrass seed in a pound of sudangrass is not likely when a quick visual examination of a handful of seed is the primary diagnosis used.

Flowability: The ease and uniformity with which the seed mass will flow in the absence of mechanical force is its flowability. A large sample of the entire lot must be used to determine flowability because compaction must be considered in addition to the presence of inert material and natural seed appendages. If flowability is based upon a sample, it should be drawn by hand because probes often exclude large pieces of inert materials which are likely to cause problems.

Seed must flow uniformly through the elevating and cleaning equipment to make an effective separation. As a general rule, a lot of seed which has an angle of repose greater than 45° should be pre-cleaned or conditioned before attempting any separation by the air-screen or other conditioning machine. Anyone who has spent a day poking seed into an elevator or through a bin opening will testify for the need of predetermining the flowability of the seed lot.

Most seed lots which have been harvested and threshed mechanically will flow through a properly designed processing plant. However, an occasional lot of most seed kinds may lack the desired flow characteristics due to natural appendages on the seed, high quantities of
stems or straw, high moisture content, or poor threshing. Such lots require pre-cleaning before attempting to separate the good seed. Scalping, drying, debearding, re-threshing or use of a hammermill may be required to obtain the desired flow characteristics of the seed mass.

Pre-Cleaning "Conditioning": Diagnosis of the need for pre-cleaning "conditioning" cleaning is usually based on a visual examination but may require a germination test. When cleaning barley, oats, and many clovers it is necessary to remove awns, hulls or other appendages before the seed can be cleaned properly.

Seed such as arrowleaf and white clovers may have few or no seed coverings to be removed but simply be very high in hard seed content. Routine scarification of otherwise clean seed is not a practice used by wise seed conditioners. Placing one hundred seed in a glass of water overnight and counting the number of swollen seed to assure that over 80% have imbibed water by the next morning is a simple way of determining the real need for scarification. In most species, 80% swollen seed in 12 hours means a hard seed content of 10% or less. Keep in mind that scarification is controlled mechanical injury so you can kill more seed than you scarify if you are not careful in your effort to eliminate the hard seed.

Damaged Seed: There are three principal causes for damaged seed: insect, disease and mechanical abuse. Only the more severely damaged of these seed can be separated mechanically, regardless of the source of damage. What is a severely damaged seed? It is a seed which has had its physical characteristics altered sufficiently to effect a separation: for example, soybean splits, weevil eaten wheat or rotten corn seed. On the other hand, damage such as cracked seed coats, abrasions, surface molds, etc., is usually not sufficient to permit mechanical separation although visually quite evident. Again, you may want to send seed lots high in damaged seed to the elevator.

A visual diagnosis with the aid of magnification may be needed to determine the need for fumigation and/or application of pesticides, as well as the possibilities for mechanical separation of the damaged seed. When insects are active in a sample, the seed lot should be fumigated before entering the conditioning plant and in most cases an insecticide applied after the seed have been cleaned. On the other hand, the application of fungicides should be based upon the farmer's need for the protection provided. Seed which are so diseased that a fungicide is needed to protect them in storage should usually be rejected for seed purposes. Remember, fungicides protect seed; but they will not bring them back to life.

Homogeneity: Most seedsmen do not test for lot homogeneity, rather they assume that a seed lot cleaned through the same set of cleaning and/or grading machines is homogenous. However, lack of homogeneity is
one of the most frequent causes of seed law violations, at least for honest seedsmen.

Diagnosis for homogeneity requires more time and effort than many companies believe they can afford. It requires that a series of sub-samples be taken from different parts, i.e., bags or bins of the lot. A visual examination and possibly a purity and germination test is made for each sub-sample, and the test results for each sub-sample are compared with that of the composite sample. A diagnosis of homogeneity should always be conducted when different kinds of varieties of seed occur naturally or are blended intentionally, i.e., lawn grass mixtures, variety blends, etc.

The source of non-homogeneous lots can usually be traced to one of four mistakes on the part of the conditioning manager. These are: open-end lots, seed from different harvest dates or locations included in the same lot, non-uniform field infestations, and "bag blending."

A lot of seed is a defined quantity of seed, identified by a lot number, every portion or bag of which is uniform for the factors which appear in the labeling. That should be the end of open-end lots but still, "fools rush in where angels fear to tread."

Either one rain shower or two combines can significantly alter the physical and biological quality of the seed harvested from a single field or two fields of the same variety. Failure to recognize the natural variation brought about by conditions and events prior to the time the seed are first bulked often means trouble. It is much less costly to change a lot number than to retag a lot so a stop sale notice is released.

One assumption made by many seed conditioners is that the seed harvested from any one production field will be uniform. Another assumption is the belief that conveying the seed from combine to truck, truck to storage bin, storage bin to air-screen holding bin, etc., blends or mixes the seed to uniformity. Routine handling of most seed lots has not, does not and will not have a significant effect on their homogeneity. The art and science of blending is very complex.

What is bag blending? It is a self-invitation to the courthouse as a defendant. The stacking of bags of seed not similar in purity or germination and/or reassignment of several lots into a single lot may appear rational to someone who doesn't understand the living seed. However, to a seedsman, bag blending is "Russian roulette" and can readily lead to the economic death of the company.
Summary

Every seed lot should be subjected to a diagnosis to determine its conditioning needs. If possible, this diagnosis should be made before the seed arrive at the conditioning plant but certainly before an effort is made to clean, upgrade, size or treat the seed. The more detailed the diagnosis the better the prognosis, provided you, as the "seed doctor", have the training, experience and equipment to cure the patient. If after a thorough diagnosis you still have a "problem lot", take two aspirin and call our secretary; she has a solution for every problem.