MAGNETIC SEPARATION EFFICIENCY IN THE FOOD & RELATED INDUSTRIES
(With notes on magnet circuit design)

Background:

The bulk of metal and magnetic fragments of concern in today's food processing are <3mm and down to 100 microns in size. Such particles and fragments can be present in surprisingly large amounts in food streams and originate from a number of sources such as: supplier raw materials, wear and tear of processing machinery and from maintenance activities. Normally, it is good practice to extract these contaminations with powerful magnets prior to metal detection and X-ray equipment. Magnets are necessary for food safety and to reduce product wastage and metal detector trips and because metal detectors often miss particles smaller than their "test piece" size and small wires if not fortunately oriented transverse in their passage through the detector's search coil.

Although metal detection and X-ray machines are effective for their purpose, without use of efficient and effective upstream magnet installations, product food safety and brand integrity are in jeopardy.

Most food plant and processing equipment is now constructed of non-magnetic 316 or 304 grade stainless steel. It is indeed fortunate and can be demonstrated that wear processes "work harden" small fragments of stainless steel, making such particles *weakly magnetic* and therefore, able to be extracted *on contact* with rare earth magnets which present flux density at pole centers above 8.5 kilogauss (when measured with a calibrated gauss meter).

"Pulling "and "holding" forces presented by a given magnet are functions of magnet circuit design. All magnets possess both in varying proportions according to the manufacturer's method.

High "pull force at distance" is not a significant factor of separation efficiency where "contact" is necessary to achieve separation. High force at distance *is* relevant when using plate magnets; drum magnets etc. to capture larger pieces of tramp iron from early in the product stream to prevent machinery damage.

High holding force, designed for very small and weakly magnetic contamination, is essential to effectively extract weakly magnetic metal, rust *and stone contaminations* encountered in the food industry of today. These fragments require "close contact" with the magnet surface to ensure high percentage extraction. It is also essential for the magnet to provide a multitude of effective relief areas - important to *retain* collected fragments against product flow until the magnet is cleaned.

The most common magnet types now used to protect sensitive food ingredient streams are: grate, probe and bar type magnets. This is because these magnet types can be engineered to present higher magnetic flux density at closer pole distances and provide best efficiency of fragment retention against product flow. Such magnets perform a vital duty prior to packaging of free flowing finished products and also prior to dough making or baking. In addition, these magnet types are used to protect liquid products such as: dairy, chocolate, soups and sauces, especially if the product contains particulate which means metal fragments below the particulate size cannot be removed by screening or filtration.

Quick cleaning and self-cleaning versions of these types of magnets are becoming more popular. This is due to the importance of the magnet surface being frequently presented clean to the product stream in order to ensure continuing separation efficiency. Magnet cleaning times are thereby reduced and less operator attention is required to optimise magnetic fragment extraction.

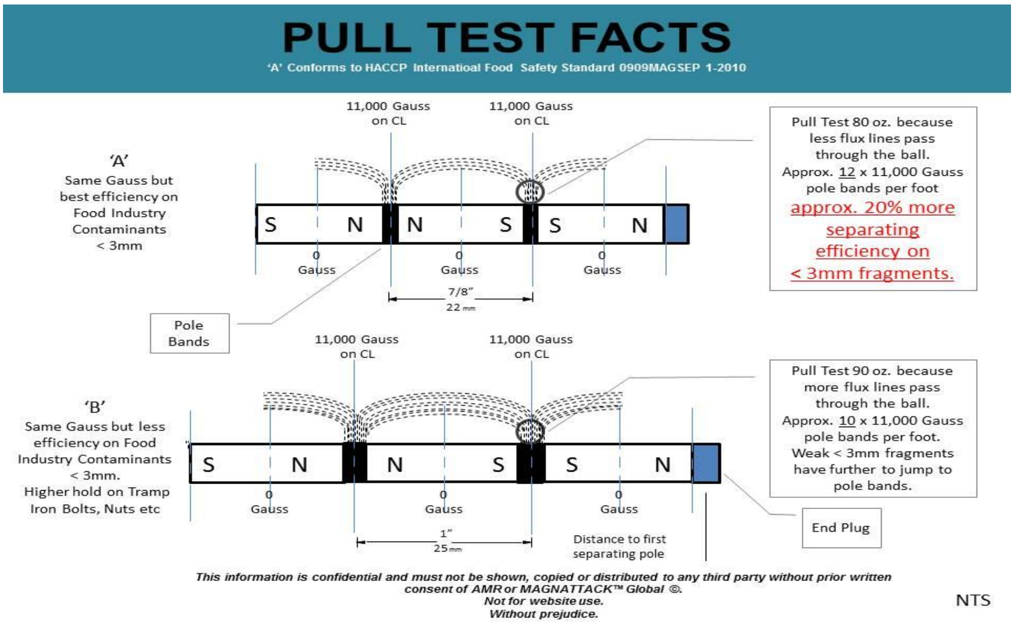
It should be noted that "sleeve type" magnets are no longer recommended for *final* magnet installations because of inherent hygiene, separation efficiency and high maintenance deficiencies.

All magnet installations must now be hygienically constructed to satisfy appropriate authorities and standards of excellence as well as ease of cleaning and sanitizing.

Points to Consider When Selecting for Magnet Effectiveness:
Significant efficiency steps for evaluating and maintaining effective food industry magnet installations are now summarized below for the assistance of quality and engineering management who have the responsibility of selecting effective new magnet installations and validating ongoing magnet reliability:

1. Compare magnet flux density at pole centers. These are the extracting and retaining bands of highest gauss.

MAGNET CIRCUIT COMPARISON



2. Carry out or request certificates from your magnet vendor of the *initial* validation of the new magnet strength (*in gauss units*) determined with a *calibrated gauss meter*. Pull test results can be misleading if used as the only basis for comparing and selecting magnets of different makes as explained on the above comparison chart and in further detail below.

3. Compare linear length of highest strength pole junctions per bar length exposed to product contact (these are the only areas on a magnet bar which extract and retain weakly magnetic fragments). Consider also how far in from bar end is the first 10,000 to 11,000 gauss pole centerline. This is where separation begins and is governed by the length of first magnet, width of pole plate and the length of the end plug retaining the magnets.

4. Compare distance between pole centers along a magnet bar. Highest efficiency magnets *minimise* the width of non-separating "*dead*" and "*lower gauss*" areas between the extracting pole junctions without compromising centreline gauss strength.

5. Arrange an ongoing in house program of verifying installed magnets by pull test *or* calibrated gauss meter to trend magnet strength loss over time. Conduct third party endorsed validations/verifications on an annual or biennial basis to meet food safety audit requirements and to support your in house verification procedures.

6. Use experienced application design assistance in the first place to achieve maximum contact of product with magnetic extraction surfaces and to avoid product flow problems.

7. Replace magnets which become unhygienic due to: corrosion, swelling and/or damage, or due to strength loss which will lead to the magnet having reduced ability to extract or retain magnetic fragments.

These important factors in points 1 to 7 deserve some further explanation and we suggest you refer to the above AMR magnet circuit comparison and the HACCP International "Food Safety Standard 0909MAGSEP 1-2010 for Final Magnetic Separation Devices for Removing Ferromagnetic and Weakly Ferromagnetic Particles from Food Product Streams." The Standard referred to requires new final magnets to have a minimum strength of 10,000 gauss when measured with a currently calibrated gauss meter with replacement required when magnet strength falls below 8,500 gauss or 15% below specification strength.

Further Explanation: FAQ's

Is an 11 or 12,000 gauss magnet more effective than say a 10,000 gauss magnet? Should I choose the highest strength?

Not necessarily. Firstly, it should be understood that there is very little increase in separating efficiency between 10,000 gauss and 12,000 gauss when the purpose of installing magnets is to extract fine, <3mm weakly magnetic particles. Please note that the small fragments of chief concern are *only* collected on these high strength pole junctions and often only on the centerline of highest gauss. The main advantage of higher than 10,000 initial gauss is the potentially longer time before magnet strength loss reduces to the standard minimum of 8,500 gauss. It should also be noted that some recent ultra-high energy magnet grades have lower "coercivity" values which means that they can lose original higher strength prematurely once in service. If specifying a grade of magnet element, it is safer to nominate a well proved technology such as RE80™ or equivalent which has track record of over 10 years strength retention above 8,500 gauss. Higher energy recent grades may be safe but have yet to be proved in service conditions.

Do rare earth magnets lose their strength over time? And how can that be minimised?

Yes, they do. Premature demagnetisation is caused by adverse factors such as heat, vibration, corrosion /oxygen absorption, thermal shock, electric alternating currents. Measures to minimise these factors include (and are not limited to): selection of proven magnet element grade, use of resin encapsulation and penetration under high vacuum, ensuring rated service or cleaning temperatures are not exceeded, double sealing against corrosion.

Should I select magnets for extracting 3mm particles based on pull test values?

No, this is not recommended. The reason is that to obtain higher pull test values, the pole plate between magnets needs to be wider than typical fragment size of 2mm and less. This extra width of pole plate allows more magnetic flux lines to pass through the selected larger pull test ball therefore resulting in a higher reading. This would be great if we only needed to extract highly magnetic ferrous balls of that size and larger from the product stream. If the essential center line gauss flux density is to be maintained when using wider pole plates, this is usually engineered at the expense of increasing the *distance between pole centerlines* along a given magnet bar. To gain further understanding of this important, but often overlooked efficiency factor, please study the circuit comparison chart provided and points 3 and 4 above listed for your guidance.

Which is the most important, "higher gauss and pull test readings" or "shortest distance between pole centrelines"

Provided centerline gauss is to specification, shortest distance between pole centerlines is the more important if the main objective is to extract <3mm fragments including weakly magnetics. This is because in a given bar length there are more catch and retain high gauss centerlines *and* because the small weakly magnetic fragments have *less* distance to travel from the mid "0 gauss" points to the high gauss collection centerlines. Please refer the circuit design sketch for better understanding of this important consideration when selecting a magnet for food safety purposes. Pole center distances are also discussed in the Standard referred to. If the primary duty is rather to collect *large highly magnetic* bolts and nuts, efficiency would be substantially the same and "high gauss or pull test readings" would be the most important. This duty however, is more the function of *upstream* tramp iron magnets or final *metal detectors.*

Should I use pull test or gauss meter methods for testing magnets?

Use calibrated versions of either method for detecting and trending magnet strength loss of existing magnets over time. Always use the same size pull test ball to compare with previous tests. Only use instruments calibrated within the previous 12 months. Verify the instrument on a "standard reference magnet" immediately prior to the testing. Only use certified gauss readings based on calibrated gauss meters when comparing magnets for purchase.
Remember the rule: *highest gauss strength at smallest gap between pole centerlines.*

Should I consider cheap imported magnetic equipment which is much lower in cost?

Certainly, but please be very careful when choosing such magnets for critical or final magnets as there are some inferior quality magnetic equipment manufacturers and importers worldwide. Consider lifetime costs, warranty, servicing, hassles and cost of premature replacement due to demagnetisation, abrasive wear, oxygen absorption and corrosion also magnets bending due to having very thin walls. In our opinion, there is scope to select heavy duty low cost alternatives for large area intake or bag opening stations where cost of certified magnets may be outside of budget allowed and magnet validation is not essential. Such magnets are usually not final magnets but perform indicating or scalping duty to relieve the load on critical downstream or final packing magnets.

Where can I purchase calibrated pull test instruments, calibrated gauss meters, obtain recalibrations, standard reference magnets, hire calibrated instruments, contract on site or remote HACCP endorsed magnet validation reports?

From Active Magnetics Research direct or from the licensed AMR agent in your area, or, refer to:
www.amrconsulting.co

Where can I obtain technical assistance on magnet requirements and equipment satisfying the criteria and standards referred to in this report?

From MAGNATTACK™ Global or its licensed distributors around the world, or, refer to:
www.magnattackglobal.com

Presented by courtesy of:
W J Baker
Senior Technical Partner and Consultant
Active Magnetics Research Pty Ltd
14th October 2014

Disclaimer: This document comprises of confidential information and must not be shown, copied or distributed to any third party without prior written consent of AMR or MAGNATTACK™ Global ©. Not for website use. Without prejudice.