

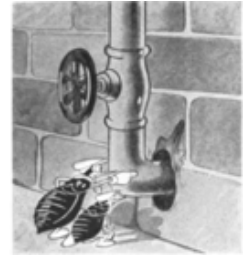
Design & Exclusion Principles for Pests of Stored Grain

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History of Exclusion

“we should have little trouble with vermin if our builders would hear and understand the ‘language’ of vermin and would do a better job in eliminating entrances and hiding places for them (Hartnack 1939).”



Hugo Hartnack, 1939
202 Common Household Pests

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The Value of Design & Exclusion

Pests and disease
Contamination
Structural damage

Prevention!



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Challenges for the Grain Industry

Common insect pests of grains are very small
Conflicts between ventilation and exclusion
Structures not designed with exclusion in mind
Exclusion can be expensive for large structures

Changing a mindset is a major challenge!

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Pest Management in Stored Grain

Emphasis to date:

- sanitation to remove food/infestations
- protective pesticide applications before binning
- protective pesticide applications after binning
- cultural controls: temperature, humidity
- monitoring to identify problems

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Design & Exclusion in Stored Grain

1. Inspection
2. Prioritization
3. Tool & Material Selection
4. Implementation
5. Evaluation

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1. Inspection

A thorough inspection is key to pest management

- Defines the scope/extent of pest problems
- Identify structural deficiencies (entry points)
- Identify pest species (specimens or evidence)
- Identify sanitation or water issues
- Establishes treatment method
- Determines what materials to use and where

Situational Pest Management: Stov Hedges IPCT Magazine, NOV 2015]

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1. Inspection: Pest Evidence

**Ideal pest harborage is
out of sight and quiet**

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1. Inspection: Identification



**Effective pest management depends on
accurate identification of the target pest**

Provides insights about nest sites, seasonal activity, food sources, reproductive capacity, foraging habits...

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1. Inspection: Life Stage



pup:
nearby indoor nest



adult male:
exterior entry point

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1. Inspection: Opening Size

rodent bodies are flexible,
their bones are not flexible.

Mice

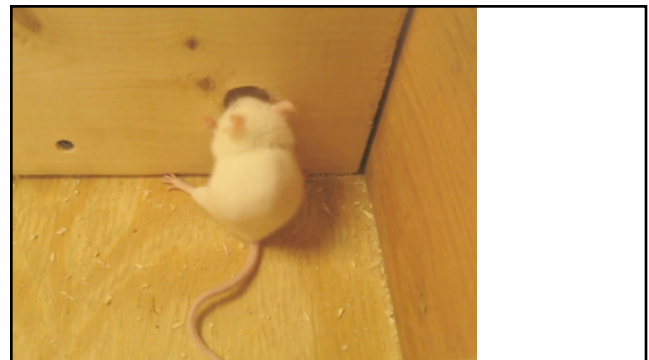
gaps > 1/4"



openings > 3/8"



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Geiger & Cox. 2012. Pest Prevention by Design: Authoritative Guidelines for Designing Pests Out of Structures. San Francisco Department of the Environment, San Francisco, CA. 89 pp.

Common Name	Scientific Name	Maximum opening size (mouth size)	Reference
Bling bling	Centropomus	0.65 m – 10 cm	Ahlborg, 2005
Cake diver	<i>Parulius</i> spp.	0.595 m – 10 cm	Reider, 1917
Blacktip	<i>Isodon</i>	0.5 m – 10 cm	Reider, 1917
Coral goby	<i>Apha</i> sp.	0.341 m – 10 cm	Matsuda & Narae, 1991
Flat fish	<i>Chirocentrus</i> sp.	2.12 m – 10 cm	NPS, 2006
Headfish	<i>Paralichthys</i>	0.5 m – 10 cm	NPS, 2006
House fish	<i>Paralichthys</i>	2.03 m – 10 cm	Matsuda & Narae, 1991
Monogob	<i>Awaia</i> sp.	1.03 m – 10 cm	Wicks, 1946; Wicks, 1956; Bales, 1964
Parrotfish	<i>Scorpaenidae</i>	0.5 m – 10 cm	NPS, 2006
Redfish	<i>Centropristis</i>	0.595 m – 10 cm	Reider, 1917
Sailfin	<i>Pseudomugil</i> sp.	0.65 m – 10 cm	Ahlborg, 2005
Sandfish	<i>Paralichthys</i> sp.	0.65 m – 10 cm	NPS, 2006
Savanna Steiner (sawtooth)	<i>Acrossocheilus</i> sp.	0.5 m – 10 cm	Tsoto, 2000*
Sturgeon	<i>Acrossocheilus</i>	0.65 m – 10 cm	Gray, 1991*
Parrotfish	<i>Paralichthys</i>	0.192 m – 47 cm	Matsuda & Narae, 1991
Tilapia	<i>Haplochromis</i> sp.	2.00 m – 7 m	NPS, 2006
Tilapia	<i>Haplochromis</i> sp.	2.00 m – 7 m	NPS, 2006
Surfsculpin	<i>Scorpaenidae</i> sp.	1.6 m	Tsoto & Ahlborg, 1992
Shark	<i>Carcharias</i> sp.	1.6 m	Tsoto & Ahlborg, 1992
Spratle	<i>Pomoxis</i> sp.	19.1 m (37.34 ft)	Tsoto & Ahlborg, 1992
Shark	<i>Carcharias</i> sp.	19.1 m (37.34 ft)	Tsoto & Ahlborg, 1992
Bass	<i>Chromis</i> sp.	6 mm to 25 in	Greenfield & Frome, 1994
Muss	<i>Awa mactulata</i>	6 mm to 25 in	Greenfield & Frome, 1994
Albacore	<i>Etmopterus</i> sp.	10 m to 12 m	Compton, 1970

*Todes had worked with a variety of different water dogs. These were matched with the closest T-bush mark size. All other fishes selected required specific to measure mark sizes. Dogs were matched with appropriate girth size. Mark sizes were measured in inches, not in feet, and all dogs were 100% male.

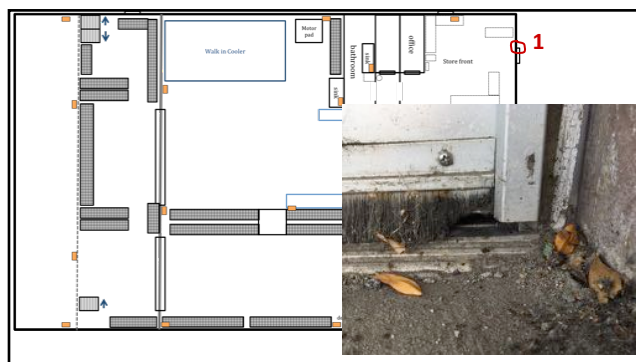
*Todes spent a preferred training facility for therapy, not minimum opening size, but the company, which is a T-bush mark.

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[illegible]

Scientific Coalition On Pest Exclusion

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[illegible]

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Exterior Openings



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Exterior: Loading Docks



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Exterior: Vegetation Management



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Exterior: Vegetation Management

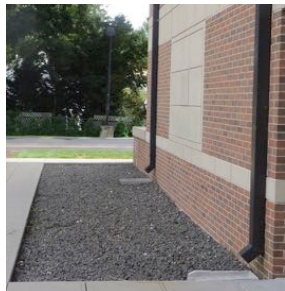
Remove vegetation within 6 to 10 feet of building

- reduces moisture and pest harborage: cover, seeds, soil for burrowing, perching sites
- prune ornamental plants to be vase-shaped

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Exterior: Vegetation Management

Vegetation Free Zones
 ~1 inch diameter stone
 2 foot wide band
 6 inches deep
 [inspection pathway]



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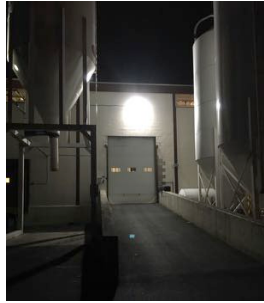
Exterior: Roof Inspection

- Air intake handlers: assess filters and screens
- Exhaust: dispersing food material?
- Access doors: often propped open
- Pooling water?
- Bird roosts?

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Exterior: Lighting

Lights are attractive to night-flying insects and their predators (spiders). Avoid placing lights above doors and other areas of entry.



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Exterior: Lighting

Location and direction of lights/lighting

- white light >50 feet from building
- motion sensor lighting or timers
- high-pressure sodium vapor lights on poles

Considering night-time visits:

- assess light profile of the structures
- look for white light escaping from building

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Interior: Sanitation



Remove food items from previous year to prevent contamination of new product.

Sanitation should be completed before exclusion is performed.

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Interior: Decommissioned Equipment

Unused items provide harborage & food residue

Clutter removal is part of sanitation and exclusion



Image courtesy of Pat Hotal, Technical Director, McCloud Services

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Interior: Drains

Dry debris can clog floor drains. Drains that dry out offer harborage to rodent and insect pests.



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Interior: Air Pressure



Negative air pressure pulls insects indoors.

Building design can alter air flow patterns.

Air curtains can limit the pull from negative air currents.


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2. Prioritization

Site Name _____		Address _____		Inspector _____	
Site Contact _____		Date _____		 <small>Integrated Pest Management Program</small>	
Category	Priority	Observation	Location	Recommendations	Image Number
Pest Sight Suspected Exclusion	1. High 2. Medium 3. Low	Describe the issue and how it contributes to pest populations	Provide details for staff to find the issue	Provide a solution to the problem you observed. What should the client do?	

Categorize
Prioritize

Observe
Locate

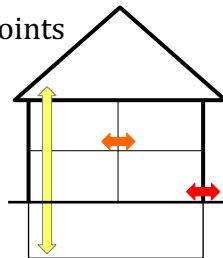
Recommend

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2. Prioritization

1. trap first to reduce the population
2. seal non-preferred entry points
3. seal primary entry point

For personal safety in
storage bins: exclusion
should only be performed
when bins are empty



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3. Material Selection

Opening size: what pest can enter?

Pest pressure: actual; potential

Environment: high use; exposure to elements

Material durability: what pests are excluded?

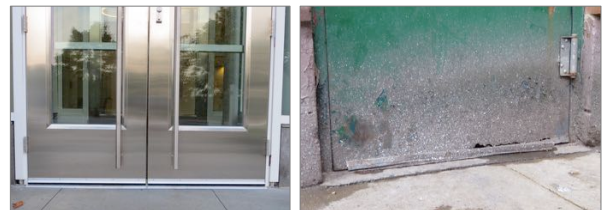
Permeability: is air flow needed? Impeded?

Expertise of employees

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Consideration: Pest Pressure

Environment and pest pressure influence
product selection and prioritization



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Consideration: Material Durability

Weatherization is *not* rodent exclusion



Rodents overcome weatherization materials:
chew, push, climb & work together

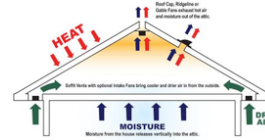
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Considerations: Permeability

Some spaces need to “breathe”

Moisture problems are an issue for grains.

However, exclusion cannot interfere with aeration and summer cooling of grains.



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Considerations: Permeability

Ventilator grills must not impede airflow



- 18-gauge, ½ inch mesh, galvanized expanded metal
- 16-gauge, ½ inch mesh, galvanized wire cloth

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4. Implementation Materials

Wildlife Exclusion Techniques that Work
Scott McNeely, Sept 2008

Tools of the Trade for Exclusion Services
Xcluder Rodent & Pest Defense, July 2017

National Wildlife Control Operators
nwco.net/training-modules/exclusion/

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Basic Exclusion

Openings less than 1 inch: anyone can do it!

- metal mesh fibers
- elastomeric sealants

Supplies:

- gloves, scissors, probe, brush/vacuum
- caulk gun, rags

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Metal Mesh Fibers

Stainless steel metal mesh fibers are abrasive for chewing rodents, do not rust



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Sealants

Must accommodate building movement

- “caulks” will dry and pull away from surfaces
- Sealants with high elastomeric value remain flexible and create a tight seal



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Instructions and product recommendations

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Intermediate Exclusion

1 to 4 inch openings; doors: some training

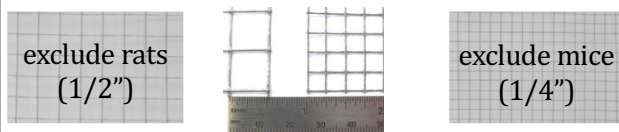
- hardware cloth
- door sweeps & astragal (vertical) seals

Supplies:

- gloves, drill, tin snips, fasteners, level, measuring tape, straight edge, brush/vacuum...

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Hardware Cloth



Woven, galvanized hardware cloth is best
Fasteners and substrate matter

- Use hex-head screws with washers
- Staple guns may not be effective
- Edges/corners can be gnawed

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Door Sweeps



High Density Brush Sweep
-prevents crawling insects
-can prevent mice



Rubber-Encased Steel Fabric
-prevents insects & rodents

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Brush Sweep Limitations



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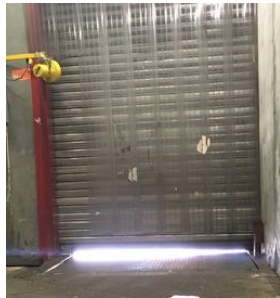
Installation Requires Experience



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Roll-Up Doors

Loading docks and garage doors require compression seals for a tight, pest-proof fit



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Advanced Exclusion

4+ inch openings, soffits/roofs, chimneys: exclusion crew w/ construction expertise

- masonry & associated tools/supplies
- carpentry & associated tools/supplies
- sheet metal & associated tools/supplies

Specifications in Pest Prevention by Design

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Special Situations: Bird Exclusion

Prevent roosting or nesting behavior

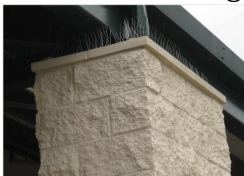


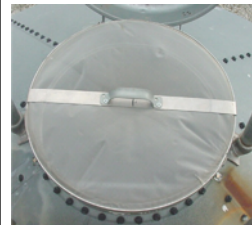
Image Courtesy of Carlos A. Campabadal, Kansas State University

Image courtesy of Joellen Lampman, NYS IPM Program, Cornell University

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Special Situations: Grain Bin Vents

Cover vents with sieve, screen or cloth that prevents insect entry and allows airflow (0.2 mm)



- check on SOP schedule
- removable screens
- vacuum accumulated debris
- use bird netting if blockages consistent/poor sanitation

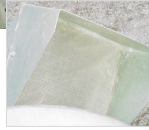
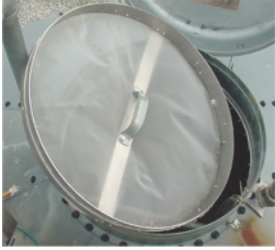
Image Courtesy of Carlos A. Campabadal, Kansas State University

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Special Situations: Grain Bin Vents

removeable screen

Downward-facing screen



Images Courtesy of Dirk Maier,
Iowa State University

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Special Situations: Grain Bin Vents

Seal inactive vents

- Louvered vents, caps and covers
- Reduces entrance of pest, moisture and heat



Images Courtesy of Dirk Maier, ISU
and Carlos Campabadal, KSU



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5. Evaluation & Documentation

What did you do and where?

Was your treatment effective?

What do you need to do in the future?

–repair and replace materials as needed

Annual inspections at least twice per year:

–Spring to assess winter damage

–Fall to verify no new entry points

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Human Behavior

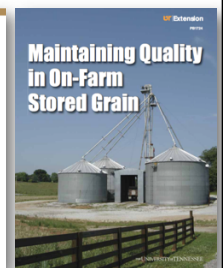
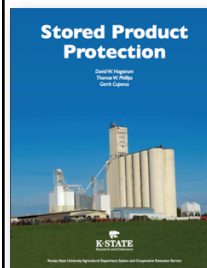
Use screens; repair when torn

Keep doors closed



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Resources



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Resources

A Review of the Impact of Artificial Light on Invertebrates

<https://www.buglife.org.uk/advice-and-publications/publications/campaigns-and-reports/review-impact-artificial-light>

BASF Master Builders Solutions: Watertight Concrete Structures

<http://www.master-builders-solutions.basf.us/en-us/functions-and-applications/waterproofing-and-sealing>

Escutcheonology 101.

<http://www.pctonline.com/article/-vertebrate-pests--escutcheonology-101/>

Exclusion: The Future of Pest Management

<http://www.pctonline.com/article/exclusion-the-future-of-pest-management/>

Exclusion Module: National Wildlife Control Operators

<http://nwco.net/training-modules/exclusion/>

Light Profiling Your Customer's Facility - Why Bother?

<http://www.pctonline.com/article/pct0313-light-profile-customers/>

Of Rodents and Doors

<http://www.pctonline.com/article/pct0815-rodent-control-doors-holes/>

PCT Guide to Commercial Pest Management

<http://store.pctonline.com/en/pct-guide-to-commercial-pest-management>

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Resources

Pest Prevention by Design

<https://sfenvironment.org/download/pest-prevention-by-design-guidelines>

Pest Prevention: Steps Designers Can Take

https://www.epa.gov/sites/production/files/2017-10/documents/peswire_fall_2017_final_optimized.pdf

Pest Proofing Small Holes.

<http://www.pctonline.com/article/-vertebrate-pests--pest-proofing-small-holes/>

Recommendations for Selecting and Using Caulks and Sealants in Pest Management Operations:

<http://www.stoppests.org/stoppests/assets/File/Corrigan%20-%20Caulk%20and%20Sealant.pdf>

Rodent-Proof Constructions and Exclusion Methods

<http://icwdm.org/handbook/rodents/RodentExclusion.asp>

Tools of the Trade for Exclusion

<http://www.pctonline.com/article/exclusion-services-tools-trade/>

Wildlife Exclusion Techniques that Work

<http://www.pctonline.com/article/-wildlife-control--wildlife-exclusion-techniques-that-work/>

Urban Ecology and Pest Management

<https://19january2017snapshot.epa.gov/sites/production/files/2016-02/documents/peswire-2015-10.pdf>

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