

正压空气过滤在高风险地区的应用实践

Application practice of positive pressure air filtration in high-risk areas

李曼中国

Science-driven solutions®

环山集团 王 帅

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❖ 空气过滤的基本原理 The basic principle of air filtration

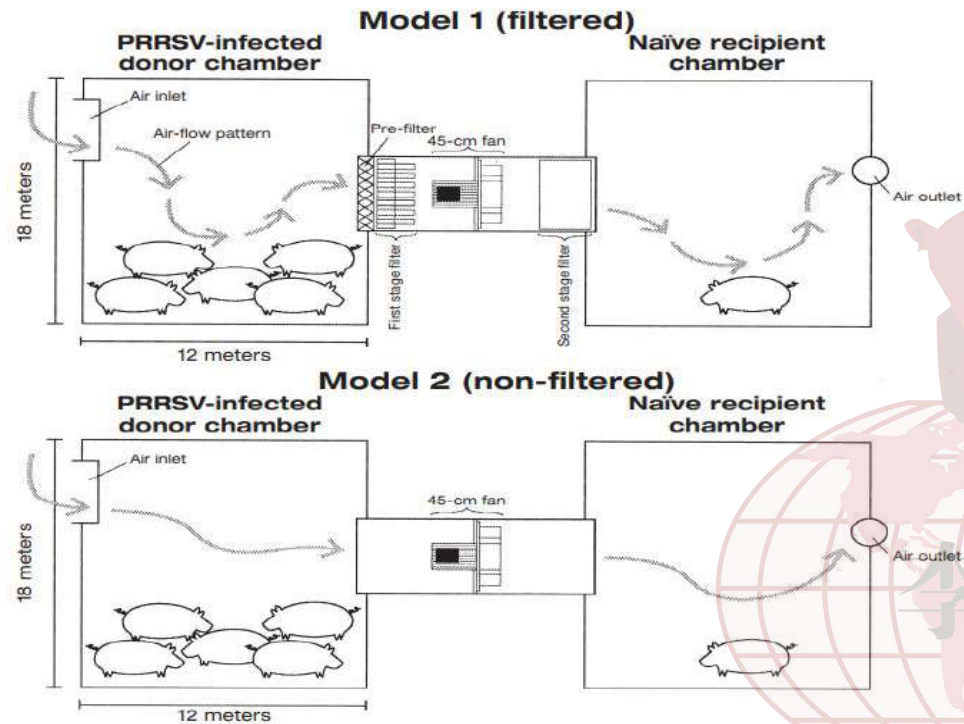
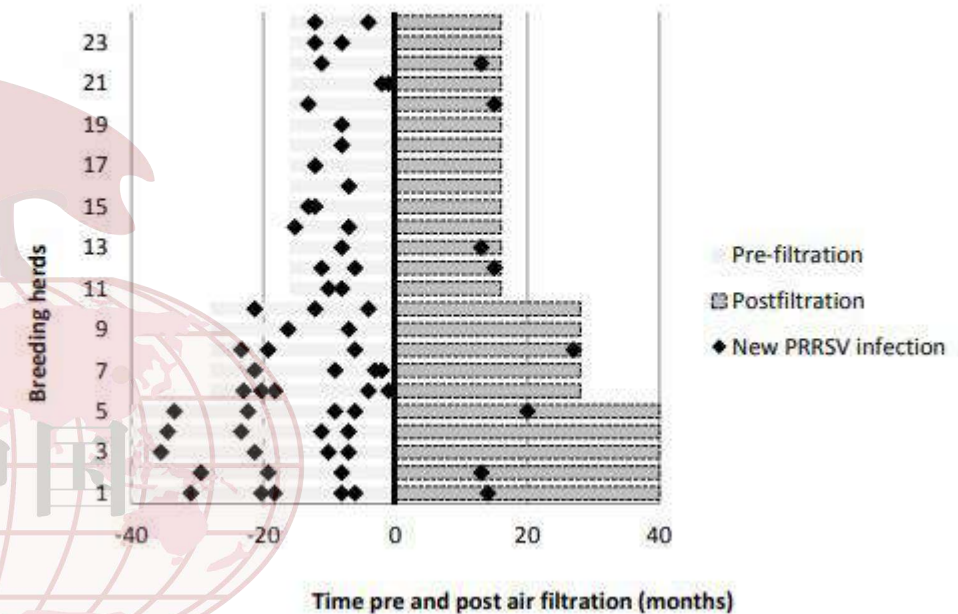


Figure 1. New porcine reproductive and respiratory syndrome virus (PRRSV) infections in breeding herds before and after the implementation of air filtration.



Dee 等人首次证明了空气过滤对预防阴性猪群（从未感染过的阴性猪群）PRRS感染的有效性。研究发现，所有供体猪均被PRRS病毒实验感染并出现了散毒，与供体猪一起饲养的哨兵猪也被证明在供体猪被有意感染后也感染了PRRS病毒。在接触了来自感染PRRS的供体单元的未过滤空气5天后，在未过滤单元中饲养的30%的受体猪中检测到了通过气溶胶传播的PRRS病毒。相比之下，在有空气过滤单元内饲养的受体猪中，在相同的暴露时间内，PRRS的感染率为0%。该差异有显著性， $P < 0.01$ 。

Dee et al. demonstrated for the first time the effectiveness of air filtration in preventing PRRS infection in negative pig populations (previously uninfected negative pig populations).

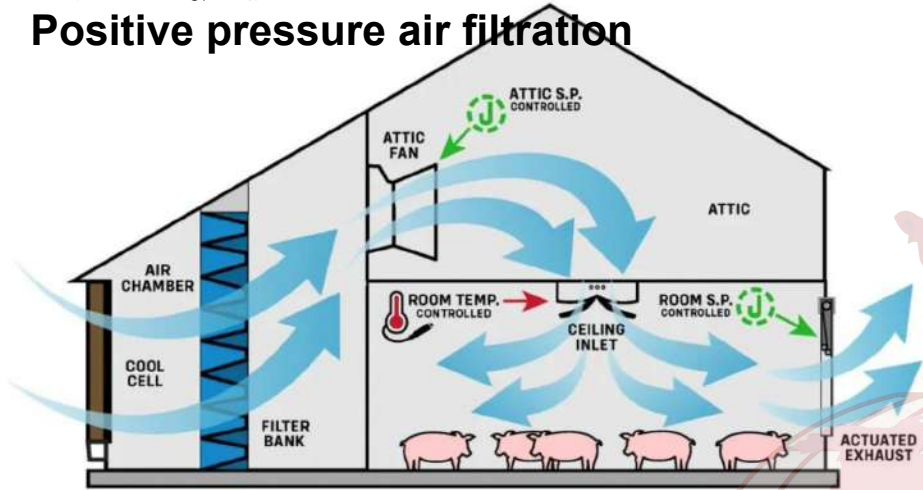
The study found that all donor pigs were experimentally infected with PRRS virus and showed scattered virus, and sentinel pigs raised with donor pigs were also shown to be infected with PRRS virus after intentional infection. After 5 days of exposure to unfiltered air from donor units infected with PRRS, PRRS virus transmitted through aerosols was detected in 30% of recipient pigs raised in the unfiltered units. In contrast, in recipient pigs raised in air filtration units, the infection rate of PRRS was 0% within the same exposure time. The difference is significant, $P < 0.01$.

2012年，Dee等人发表了一项关于空气过滤作为一种降低猪密集地区母猪场爆发PRRS风险的长期可持续性研究⁷。38个参与该研究的猪场被分成4个独立的同期组，并对每个猪场的PRRS爆发情况进行了为期41个月的监测。这些猪场分组的依据是空气过滤状况、母猪数量和猪群密度。有空气过滤的猪群的新PRRS感染显著低于同期的无空气过滤的对照猪群($P < 0.01$)。使用空气过滤前、后相同时间内繁殖群新PRRS感染的情况如下图所示。在同一猪场，使用空气过滤之前PRRS感染的几率比使用空气过滤之后的感染几率高出7.91倍。

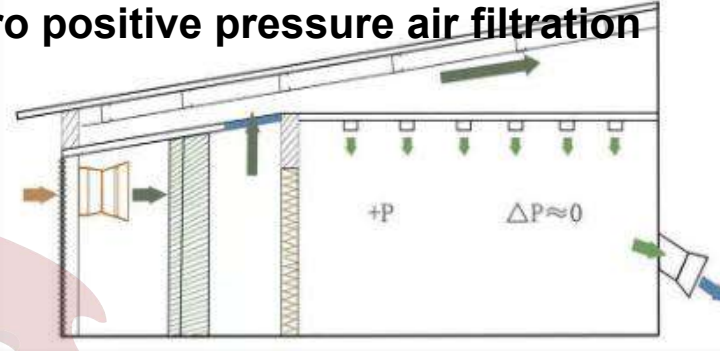
In 2012, Dee et al. published a long-term sustainability study on air filtration as a way to reduce the risk of PRRS outbreaks in pig intensive areas of sow farms. 38 pig farms participating in the study were divided into 4 independent contemporaneous groups, and PRRS outbreaks were monitored for 41 months in each farm. The grouping of these pig farms is based on air filtration conditions, number of sows, and pig population density. The new PRRS infections in pig herds with air filtration were significantly lower than those in control pig herds without air filtration during the same period ($P < 0.01$). The situation of new PRRS infections in the breeding population before and after using air filtration at the same time is shown in the following figure. The probability of PRRS infection before using air filtration in the same pig farm is 7.91 times higher than that after using air filtration.

❖ 空气过滤的几种类型 Several types of air filtration

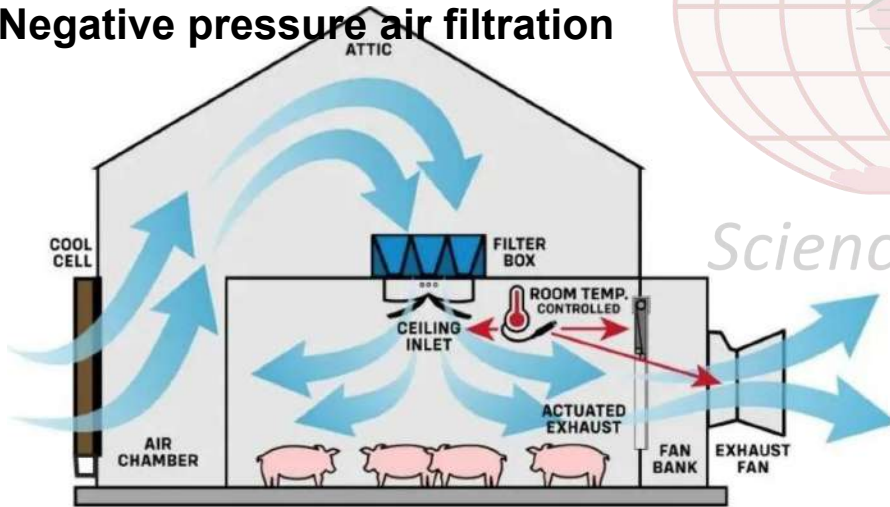
- 正压空气过滤
- Positive pressure air filtration



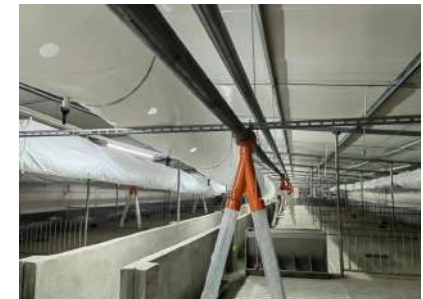
- 微正压空气过滤
- Micro positive pressure air filtration



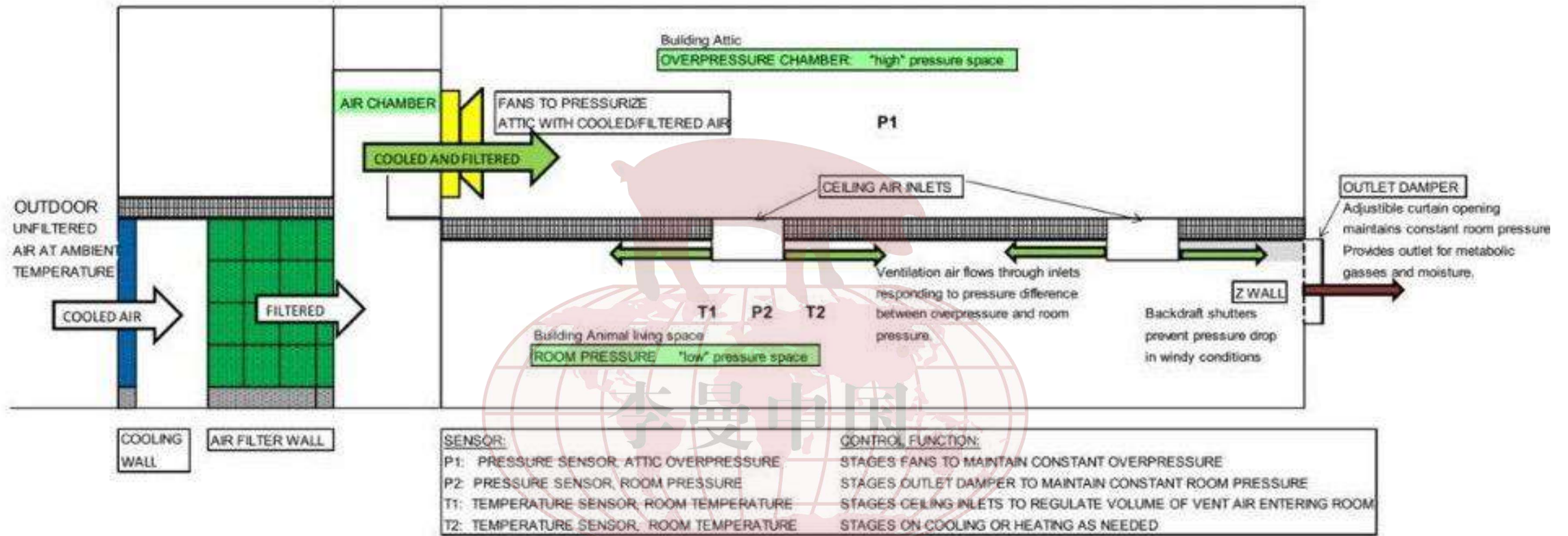
- 负压空气过滤
- Negative pressure air filtration



- 过滤系统的样式
- Style of filtering system

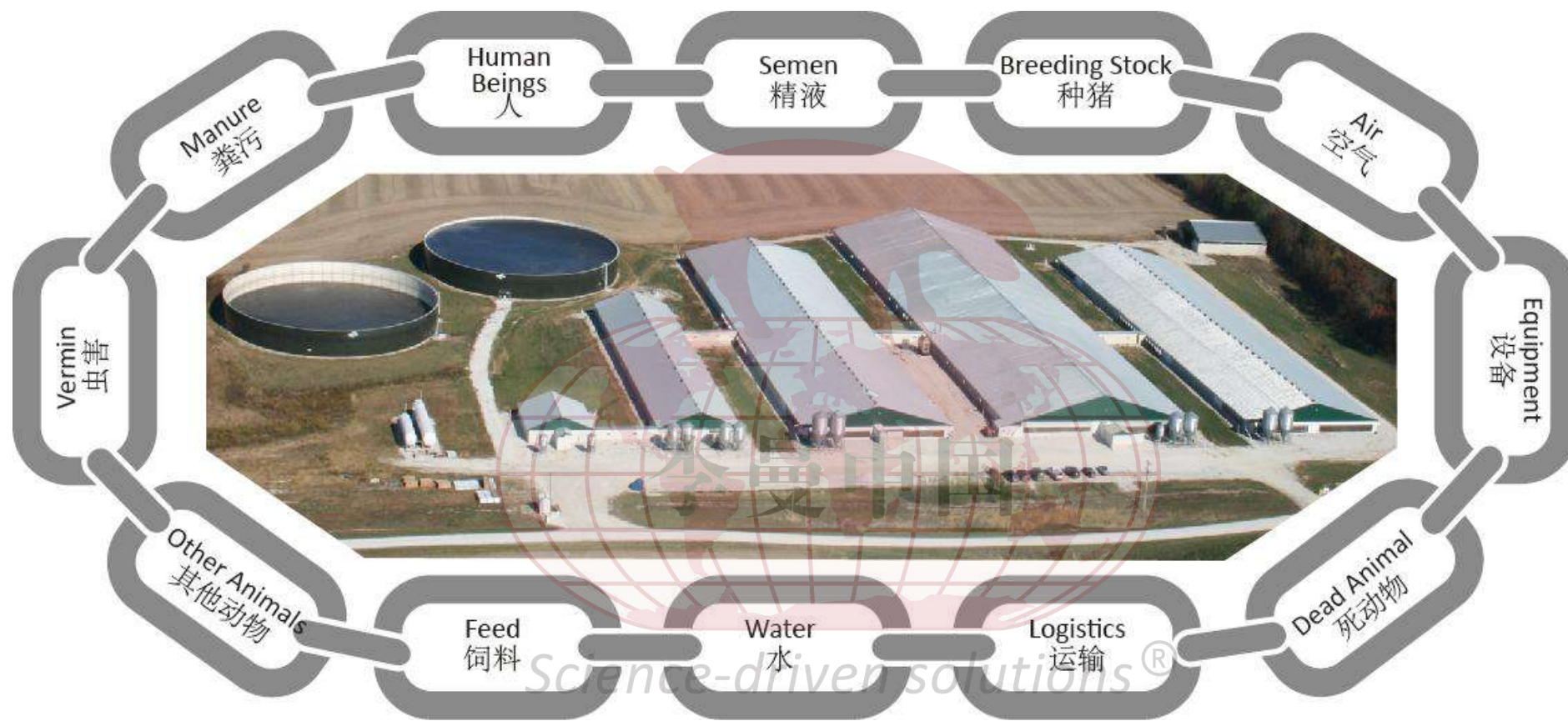


❖ 经典正压空气过滤 Classic positive pressure air filtration



- 全球范围内，正压空气过滤系统是更多猪场的选择，通常维持舍内25-35PA的正压，且要求保持稳定。这主要取决于出风口要维持一定的风速，另外，也需要确保即使在最小通风量的时候，保持一定的舍内空气更新的频率。
- Globally, positive pressure air filtration systems are the preferred choice for more pig farms, typically maintaining a positive pressure of 25-35PA within the facility and requiring stability. This mainly depends on maintaining a certain wind speed at the air outlet, and also ensuring a certain frequency of air renewal in the building even at the minimum ventilation volume.
- 正压空气过滤使用相对简单，主要包括1) 基本元件构成比较简单，容易实现全自动的控制；2) 生产管理，例如人员、猪只、物资等进出比较方便；3) 容错空间较大。
- Positive pressure air filtration is relatively simple to use, mainly consisting of 1) simple basic component composition, making it easy to achieve fully automatic control; 2) Production management, such as convenient entry and exit of personnel, pigs, materials, etc; 3) The fault tolerance space is relatively large.
- 正压空气过滤也有一些劣势，主要包括1) 对于风机的要求较高，实际运行过程中风机的静压荷载往往会超过200PA；2) 前期投资成本较高，猪舍的气密性要做好、过滤器数量多保障通风量、猪舍的钢结构投资较高；3) 运营成本相比负压过滤较高，包括电费、过滤器更换等。
- Positive pressure air filtration also has some disadvantages, mainly including 1) higher requirements for the fan, and the static pressure load of the fan during actual operation often exceeds 200PA; 2) The initial investment cost is relatively high, and the airtightness of the pigsty needs to be done well. The number of filters should be sufficient to ensure ventilation, and the steel structure investment of the pigsty is relatively high; 3) The operating costs are higher compared to negative pressure filtration, including electricity bills, filter replacement, etc.

❖ **空气过滤不是百分百的保障，而是生物安全体系的一个环节**
Air filtration is not a 100% guarantee, but a part of the biosafety system



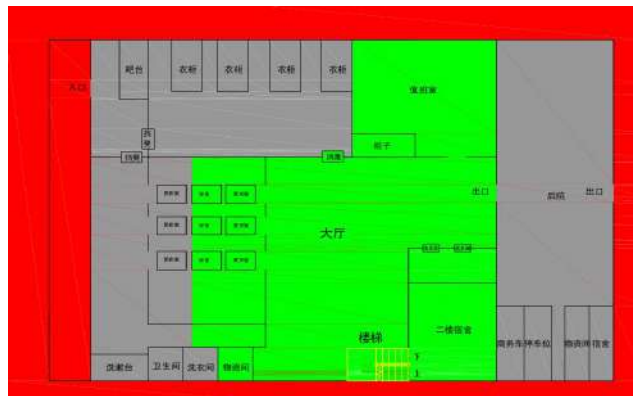
The strength of biosecurity Chain is determined by the weakest link.
生物安全体系的强度取决于最薄弱的一环。

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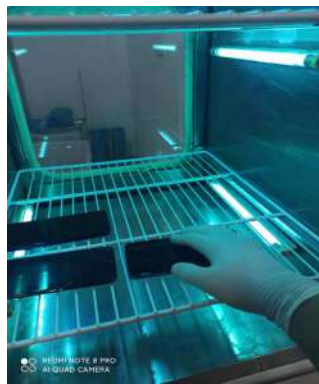
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猪 场 生 物 安 全 体 系 设 计：配套设施

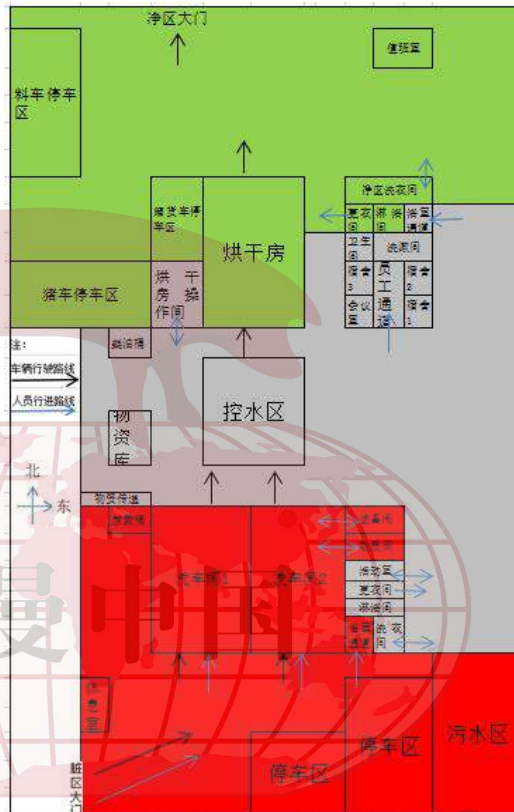
进场人员隔离点建设



- 脏区、净区分
Classification of dirty and clean areas
- 三段式洗澡通道
Three section shower channel
- 行李存储柜
Luggage storage cabinet
- 紫外线传递窗、高温烘箱
UV transmission window, high-temperature oven
- 挡凳的设置
Setting of stool
- 初级洗消设施
Primary decontamination facilities



车辆及洗消中心



- 单向流动;
Unidirectional flow;
- 有效划分脏净区;
Effectively divide dirty and clean areas;
- 三段式洗澡通道;
Three section bathing channel;
- 洗车间、烘干房、值班室等;
Car wash room, drying room, duty room, etc;
- 烘干温度实时监测
Real time monitoring of drying temperature
- 紫外线传递窗;
UV transmission window;
- 备用供水、供电
Backup water and power supply





正压空气过滤猪场的设计原则

Design principles for positive pressure air filtration pig farms

- 生产需求 Production demand
 - 生产节律选择：单周批次生产、多周生产
 - Production rhythm selection: single week batch production, multi week production
 - 基本的生产目标设置，要保障猪场的未来潜力，应以未来10年的指标来设定，包括分娩率、产仔数等
 - The basic production goals should be set based on indicators for the next 10 years to ensure the future potential of the pig farm, including delivery rate, litter size, etc
 - 动物物流设置。例如是否要固定的配种区域？对于核心群体来说，是否要有单独的母猪测定区域？是否要进行闭群生产？
 - Animal flow setting. For example, do we need a fixed breeding area? Do we need a separate sow testing area for the core population? Do you want to conduct closed group production?
- 生物安全需求 Biosafety requirements
 - 群体健康管理的目标是什么？PPRS、PED要以什么状态来启动？未来一旦转阳后该如何处置？
 - What is the goal of group health management? In what state should PPRS and PED be activated? How should we deal with it once it turns positive in the future?
 - 外部生物安全，如何将外部风险最大限度降低？这要考虑猪场配套设施该如何配置。
 - How to minimize external risks in external biosafety? This depends on how the supporting facilities of the pig farm should be configured.
 - 内部生物安全措施，一旦外部风险失效，如何避免更大的损失。内部扩散目前来看，对于ASF防控更具有价值。
 - Internal biosafety measures, how to avoid greater losses once external risks fail. At present, internal diffusion is more valuable for ASF prevention and control.
 - 结合内外部生物安全要求，进行合理分区。合理分区后的处置逻辑很明确，但凡跨区（从低到高）必须有处置措施。
 - Reasonably partition based on internal and external biosafety requirements. The disposal logic after reasonable partitioning is very clear, and there must be disposal measures for any cross district (from low to high).
- 成本需求 Cost requirements
 - 建筑结构形式该如何选择？条件允许的情况下，尽量选择大跨度的猪舍。How to choose the form of building structure? If conditions permit, try to choose a pigsty with a large span.
 - 设备选型，并不是最贵的就是最好的，但一定不是越便宜越好。Equipment selection is not necessarily the most expensive, but it is not necessarily the cheaper the better.
 - 降本的前提是保障猪场的生产需求，要满足未来猪场效率提升。**千万不要做成本转移的事情。**
 - **The premise of cost reduction is to ensure the production demand of pig farms and meet the efficiency improvement of pig farms in the future. Never do anything about cost transfer.**
 - **猪场的设计使用年限是多少？What is the design service life of the pig farm?**

正压空气过滤猪场的设计要点-过滤级别的选择 Design points of positive pressure air filtration pig farm – selection of filtration level

表2：不同粒径范围和空气采样器的RT-PCR结果和病毒分离结果。来自急性感染猪的流感病毒和PRRSV的RT-PCR（逆转录聚合酶链反应）和病毒分离阳性样本，以及生物检定法检测的PEDV阳性样本。结果用不同粒径范围（安德森级联冲击器采样）分类呈现。

病毒		安德森级联冲击器采样(粒径范围，微米)								样本数总计	气旋采样器总计
		0.4-0.7	1.1-0.7	1.1-2.1	2.1-3.3	3.3-4.7	4.7-5.8	5.8-9.0	9.0-10.0		
猪流感	1PCR	*6/15 (40.0%)	3/15 (20.0%)	5/15 (33.3%)	6/15 (40.0%)	12/15 (80.0%)	12/15 (80.0%)	13/15 (86.7%)	13/15 (86.7%)	70/20 (58.8%)	14/15 (93.3%)
	2VI	0/6	0/3	0/5	1/6 (16.7%)	1/12 (8.33%)	6/12 (50%)	4/13 (30.8%)	8/13 (61.5%)	20/70 (28.6%)	5/14 (35.7%)
PRRSV	PCR	1/34 (2.9%)	0/34	0/34	1/34 (2.9%)	2/34 (5.9%)	1/34 (2.9%)	2/34 (5.9%)	7/34 (20.6%)	14/272 (5.1%)	8/34 (23.5%)
	VI	0/1	0	0	1/1 (100%)	2/2 (100%)	1/1 (100%)	0/2 (0%)	7/7 (100%)	11/13 (84.6%)	6/8 (75%)
PEDV	PCR	6/6 (100%)	6/6 (100%)	6/6 (100%)	6/6 (100%)	6/6 (100%)	6/6 (100%)	6/6 (100%)	6/6 (100%)	48/48 (100%)	6/6 (100%)
	生物鉴定法	#NA	NA	NA	NA	NA	NA	NA	NA	NA	&3/3 (100%)

1PCR: 逆转录聚合酶链反应检测结果（包括CT值低于40的样本）。

2VI: 病原分离的结果。

*阳性样本占检测的总样本数的比例（%）。

#NA: 不适用。

&用RT-PCR 阳性空气样本接种易感猪以进行生物鉴定法检测。

Science-driven solutions®

在选择过滤器效率时，最重要的是要看对1.0 - 3.0微米颗粒的过滤效果。在美国，通常使用MERV 15过滤器(能有效过滤90%的1.0 - 3.0微米颗粒)。在高价值资产的猪场中(如公猪站、扩繁场)，一般使用MERV 16过滤器(能过滤95%的0.3-1.0微米颗粒)。MERV15过滤器的过滤效率较高，并且压降也在可接受范围，因此综合来说是一个比较好的选择。

When choosing filter efficiency, the most important thing is to consider the filtering effect on 1.0-3.0 micron particles. In the United States, MERV 15 filters are commonly used (which can effectively filter 90% of 1.0-3.0 micron particles). In high-value asset pig farms such as boar stations and breeding farms, MERV 16 filters (capable of filtering 95% of 0.3-1.0 micron particles) are generally used. The MERV15 filter has a high filtration efficiency and an acceptable pressure drop, making it a good choice overall.

❖ 正压空气过滤猪场的设计要点-过滤器的选择

Design points of positive pressure air filtration pig farm – filter selection

比较理想的空气过滤器：An ideal air filter:

- 35PA左右的初始风阻条件下，能够具有1200m³/h的风量；
- Under the initial wind resistance condition of around 35PA, it can have an air volume of 1200m³/h;
- 过滤效率不应随时间快速下降，正常情况下，初效过滤器每年更换2-3次，亚高效2-3年更换一次；
- The filtration efficiency should not decrease rapidly over time. Under normal circumstances, the primary filter should be replaced 2-3 times a year, and the sub high efficiency filter should be replaced every 2-3 years;
- 容尘量要符合要求，真正决定空气过滤器寿命的是容尘量；
- The dust holding capacity must meet the requirements, and it is the dust holding capacity that truly determines the lifespan of the air filter;
- 机械式过滤，而非静电吸附，丙酮浸泡测试。
- Mechanical filtration instead of electrostatic adsorption, acetone immersion test.



初效过滤器：Primary filter

- MERV8、28-32折；
- MERV8, 28-32% off;
- 纸质边框（防水）；
- Paper border (waterproof);
- 固定压条需要优化，扩大有效过滤面积。
- The fixed pressure strip needs to be optimized to expand the effective filtering area.



亚高效过滤器：Sub efficient filter:

- MERV15、滤纸展开面积不低于21平；
- MERV15、The unfolded area of the filter paper shall not be less than 21 square meters;
- 塑料边框需要满胶，且耐高温；
- The plastic frame needs to be fully glued and resistant to high temperatures;
- 滤纸材料建议使用玻璃纤维；
- It is recommended to use glass fiber as the filter paper material;
- 固定框架为不锈钢，4*4，主体框架为木质框架；
- The fixed frame is made of stainless steel, 4 * 4, and the main frame is made of wood;
- 密封垫为椭圆形，且一体成型，不要拼接。
- The sealing gasket is oval shaped and integrally formed, do not splice.



正压空气过滤猪场的设计要点-风机的选择

Design points of positive pressure air filtration pig farm – selection of fans

Type	Speed 100%					Speed 90%					Speed 80%				
Test	Qv	Psf	P1	n	I	Qv	Psf	P1	n	I	Qv	Psf	P1	n	I
Point	[m3/h]	[pa]	[w]	[rpm]	[A]	[m3/h]	[pa]	[w]	[rpm]	[A]	[m3/h]	[pa]	[w]	[rpm]	[A]
1	32148	50	2148	1105	3.31	28400	50	1598	990	2.49	24740	50	1175	880	1.87
2	31803	60	2193	1105	3.37	28030	60	1638	990	2.54	24300	60	1208	880	1.92
3	31454	70	2238	1105	3.44	27650	70	1677	990	2.60	23840	70	1238	880	1.96
4	31107	80	2287	1105	3.51	27230	80	1712	990	2.66	23380	80	1269	880	2.01
5	30755	90	2333	1105	3.58	26850	90	1754	990	2.72	22890	90	1298	880	2.05
6	30391	100	2377	1105	3.64	26400	100	1786	990	2.77	22410	100	1329	880	2.09
7	30020	110	2421	1105	3.71	26000	110	1826	990	2.83	21900	110	1361	880	2.14
8	29641	120	2461	1105	3.77	25550	120	1861	990	2.88	21380	120	1394	880	2.19
9	28514	150	2576	1105	3.94	24100	150	1966	990	3.03	19650	150	1485	880	2.32
10	26263	200	2780	1105	4.25	21550	200	2142	990	3.30	16400	197	1602	880	2.50
11	25157	225	2878	1105	4.40										
12	24054	250	2971	1105	4.53										
13	21525	300	3120	1105	4.76										

- 正压空气过滤对于风机性能的要求较高，不但要求其运行稳定，故障率低，同时还要求对于高静压工况的通风能力。
- Positive pressure air filtration has high requirements for fan performance, not only requiring stable operation and low failure rate, but also requiring ventilation capacity for high static pressure conditions.
- 一般情况下，风机需要应对的静压包括：三防网（5PA）、初效亚高效（35-100PA）、水帘（15PA）、阁楼压力（50PA），最高可超过200PA的环境。
- In general, the static pressure that fans need to deal with includes: three proof net (5PA), initial and sub high efficiency (35-100PA), water curtain (15PA), attic pressure (50PA), and environments that can exceed 200PA at most.
- 由于静压较高，通常会选择风机的尺寸不高于36寸。
- Due to the high static pressure, the size of the fan is usually chosen to be no more than 36 inches.

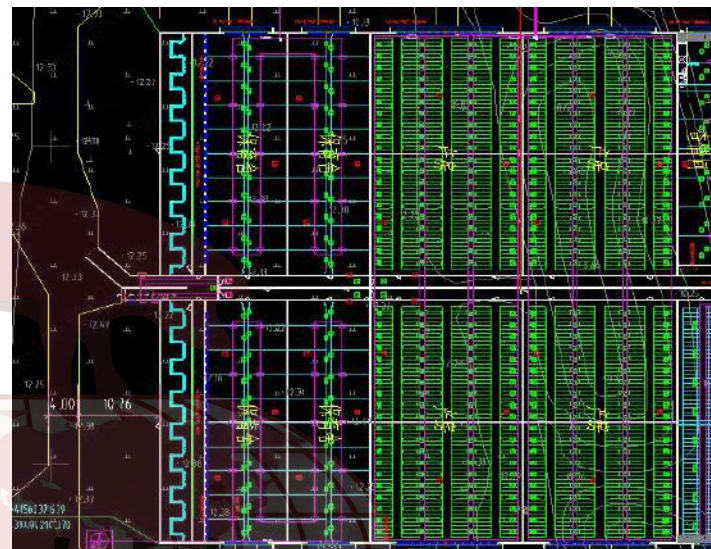
正压空气过滤猪场的设计要点

Design points of positive pressure air filtration pig farm

1、小间化设计 1. Small scale design



3、出猪台的设计 3. Design of pig platform



出猪台是空滤猪场关注的重点，要点包括：
The pig outlet is a key focus of attention for air filtration pig farms, including:

- 分段式管理，包括空气流动
Segmented management, including air flow
- 密闭门的选择，翻板气密门是比较好的选择
The choice of airtight door, flap airtight door is a better choice
- 单独设计污水和加热消毒功能
Independently design sewage and heating disinfection functions

2、挡风墙 2. Windbreak wall



4、聚氨酯喷涂 4. Polyurethane spray coating

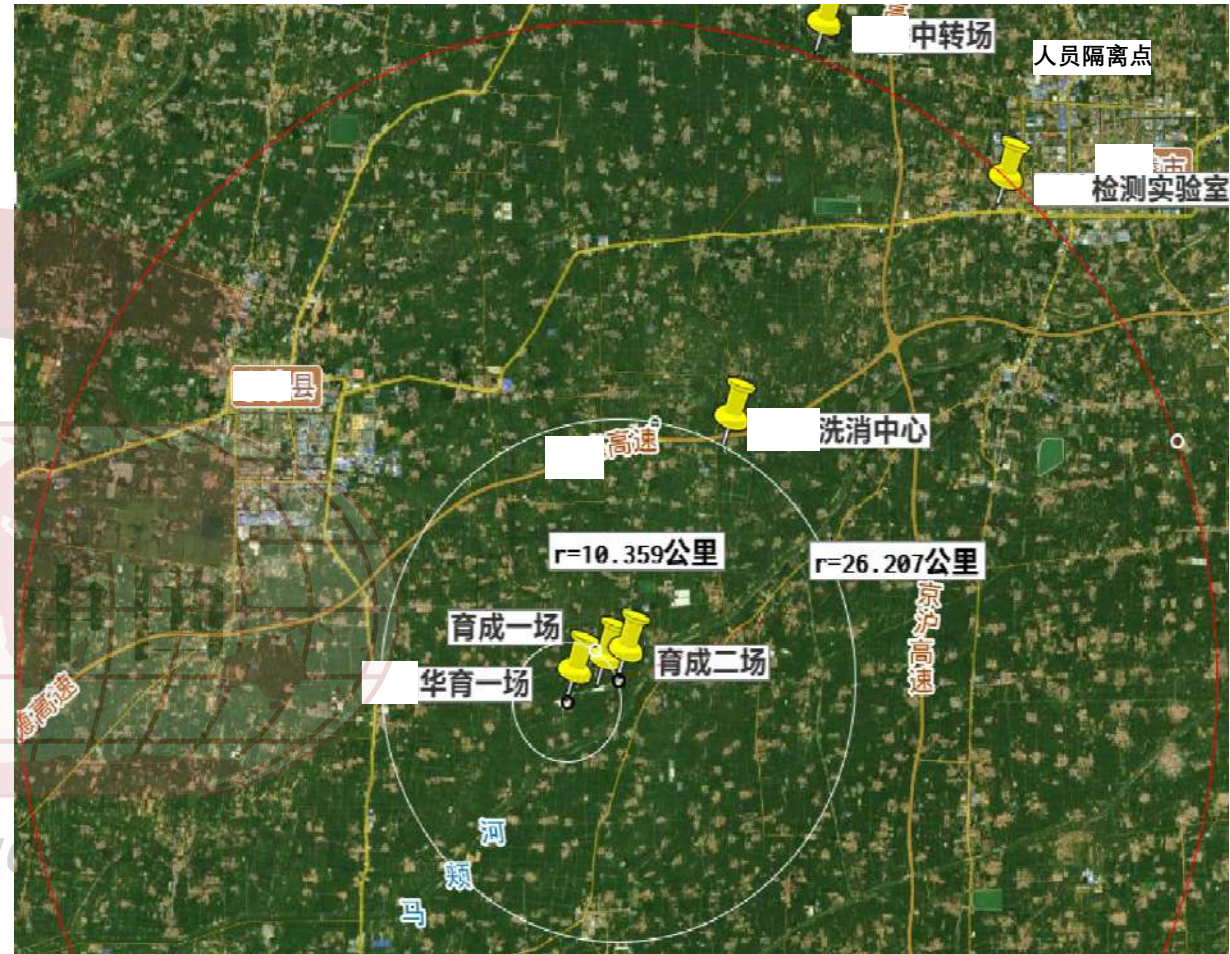
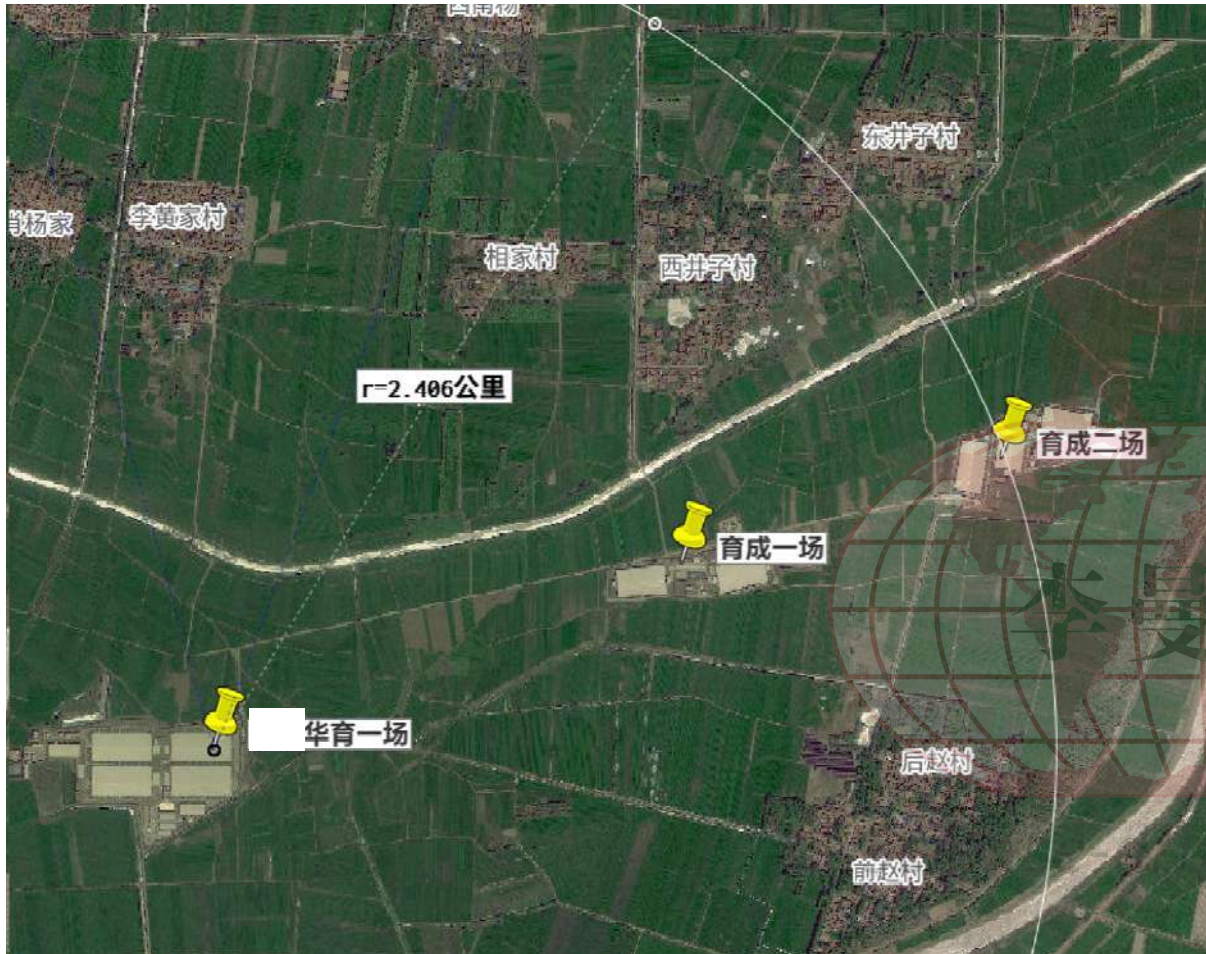


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❖ 空滤应用案例-配套设施

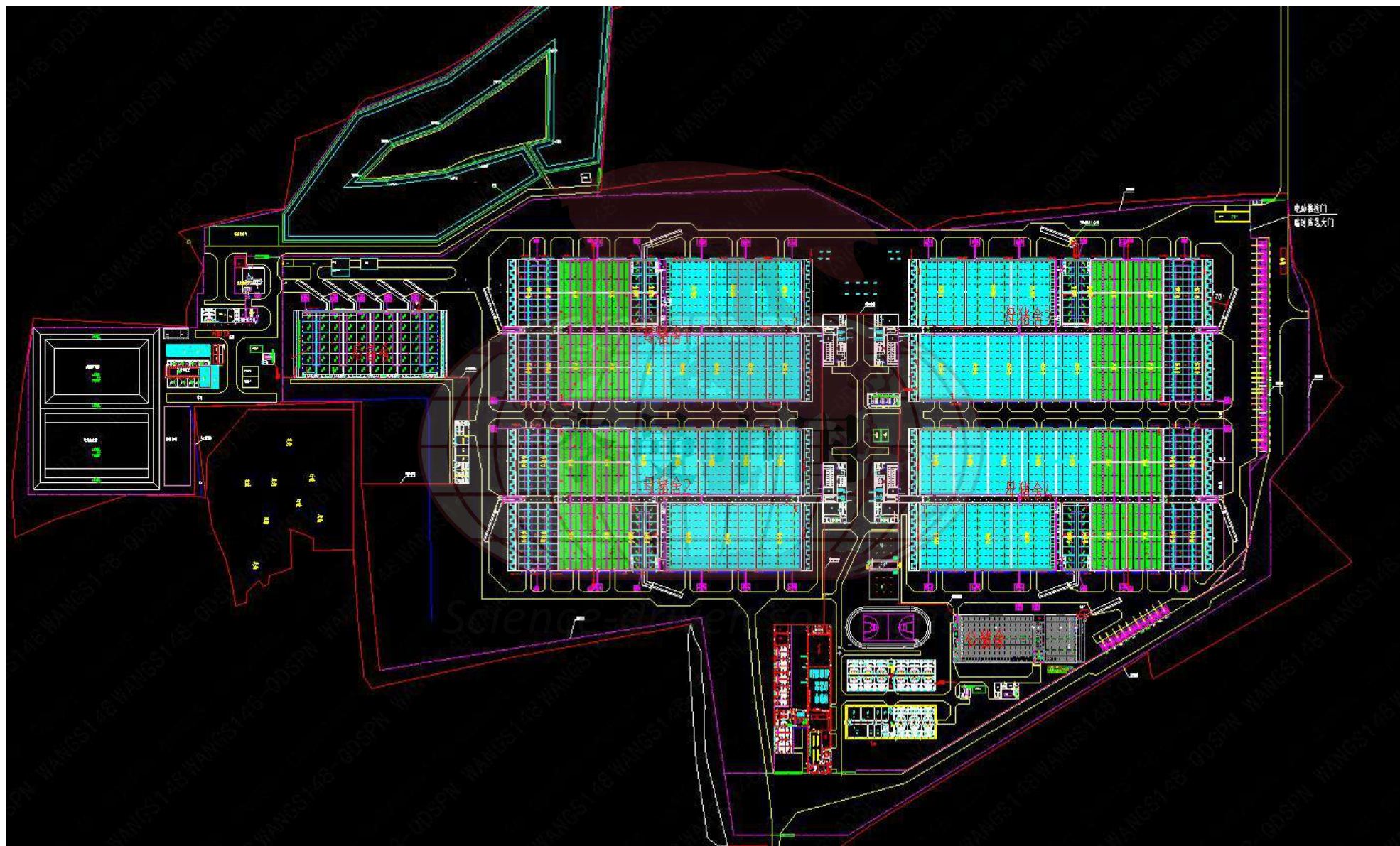
Application Case of Air Filter – Supporting Facilities



该正压空滤聚落3个猪场在2.5公里半径圈内；洗消中心在猪场10公里半径圈内；检测实验室在猪场30公里半径圈内。

The positive pressure air filter settlement has three pig farms within a radius of 2.5 kilometers; The decontamination center is located within a 10 kilometer radius of the pig farm; The testing laboratory is located within a 30 kilometer radius of the pig farm.

❖ 正压空滤母猪场 Positive pressure air filter mother pig farm



以上内容仅为本文档的试下载部分，为可阅读页数的一半内容。如要下载或阅读全文，请访问：<https://d.book118.com/605101104220012121>